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MICROWAVE LANDING SYSTEM PHASE III

(Basic Narrow and Small Community Configurations)

JUNE 1978

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Volume II

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16. Abstract

Appendix A describes the design considerations that were applied to the Rotman lenses used in a Basic (Narrow) and a Small Community configuration for the Microwave Landing System. Appendices B thru E contain a detailed reliability and maintainability analysis of the two configurations including the airborne equipments.

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Microwave Landing System, Basic Narrow Configuration, Small Community Configuration, Reliability, Maintainability

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SUMMARY

The Bendix Communications Division of The Bendix Corporation, was tasked, as prime contractor under DOT/FAA Contract DOT-FA72WA-2801, to design and fabricate two prototype Microwave Landing System configurations and to install them at the National Aviation Facilities Experimental Center (NAFEC) at Atlantic City, New Jersey.

The Basic Narrow configuration included ground azimuth, ground elevation, and DME subsystems and four airborne receivers. The Small Community configuration included ground azimuth and elevation elements and four airborne receivers.

The task has been successfully completed with the Basic Narrow and Small Community Ground Subsystems delivered to NAFEC in May 1976 and July 1976, respectively. The airborne subsystems have been installed and evaluated in numerous test aircraft. Independent field and flight testing by FAA (NAFEC) and Bendix personnel have proven that both systems meet or exceed the specified performance requirements.

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Appendix A

Design Considerations for

Rotman Lens Antennas

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APPENDIX A

DESIGN CONSIDERATIONS FOR ROTMAN LENS ANTENNAS

A.1 INTRODUCTION

Rotman and Turner[1] have derived various geometric relationships to minimize the phase aberrations across the aperture of a one-dimensional microwave lens antenna. In their work, they consider a lens in which the inputs consist of several horns, each of which generates a discrete beam in the far field. Scanning is accomplished by mechanically moving a horn along the focal arc.

For the MLS application, electronically steerable Rotman lens antennas were built. The inputs for these lenses consist of a number of closely spaced probes along the focal arc. The probes are spaced closely enough that exciting several simultaneously results in a single beam in the far field. Fine scanning is accomplished by electronically commutating a weighting function across the input probes. Design of a commutated lens posed several problems which are not considered in Rotman's work:

(a) How closely spaced should the input probes be?

(b) How many inputs should be simultaneously excited to generate a beam?

(c) With that amplitudes and phases should the inputs be excited?

In addition to these problems, other problems were involved in determining an optimum lens geometry. Given a desired beamwidth and maximum steering angle, Rotman's equations do not yield a unique solution. One must specify three addition parameters (f, α, and g -- see Reference (1)) in order to uniquely

1. Rotman and Turner, "Wide-Angle Microwave Lens For Line Source Applications", IEEE Transactions on Antennas and Propagation, November, 1963.

determine a lens design. Although Rotman offers some suggestions for appropriate values for these parameters, careful consideration must be given to their selection. It is the purpose of this appendix to explain how these problems were approached in the design of the MLS Rotman lens antennas.

A.2 COMPUTER SIMULATION

The major tool used in the design of the MLS Rotman lens antennas was a computer program BPORT. Given various lens design parameters (focal length, aperture size, etc.) BPORT used Rotman's equations to determine the contours of a lens antenna. The user could specify any combination of excitations on the inputs and BPORT would compute the resultant aperture distribution and far field pattern. Use of this program provided a means of evaluating the effects of different input weighing functions, input probe spacings, lens geometries, etc.

A second useful computer program was BPOR2. This program is essentially the inverse of BPORT. Whereas BPORT used given input excitations to compute a resultant far field pattern, BPOR2 used a given far field pattern (e.g., Taylor beam) to compute the required input excitations.

A.3 APPROACHES TO PROBLEMS

A.3.1 Lens Geometry

Given a desired beamwidth and maximum steering angle, Rotman's equations do not yield a unique lens design. One of the MLS lens design problems was to determine optimum Rotman lens design for a given application. Knowledge of the beamwidth, frequency, and maximum steering angle determines the number of aperture elements and the interelement spacing. Complete determination of a lens design requires the specification of three additional parameters: f, the focal length; α, the off-axis angle of perfect focus; and g, the ratio of the lens dimension from front to back to the focal length. In order to

minimize phase aberrations across the lens aperture, Rotman made the following recommendations:

(a) α should be near the maximum scan angle

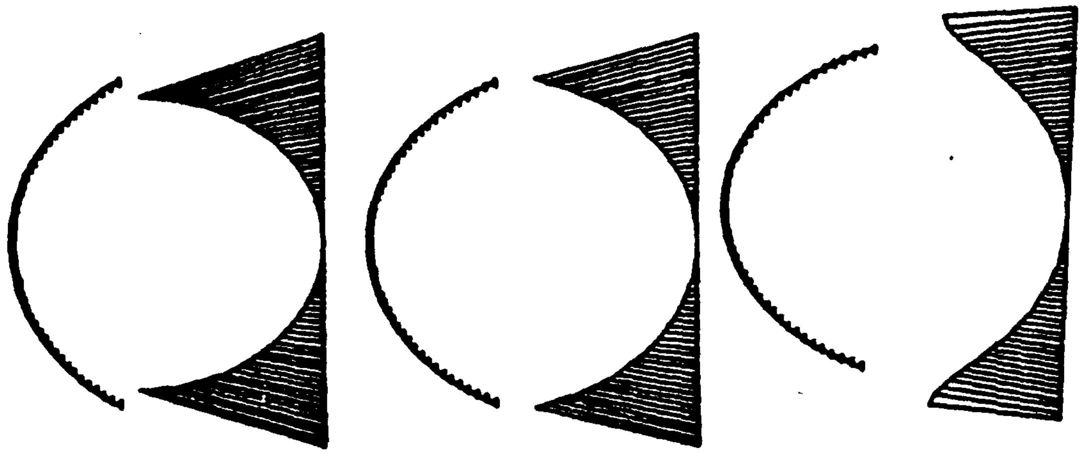
(b) f should be approximately equal to the aperture size (Rotman built a lens in which the focal length was 83% of the aperture size)

(c) g should be equal to $1 + \alpha^2/2$

Rotman recommended these values in order to keep the maximum phase aberration less than ±0.003 of the focal length (less than 2° for the Basic Narrow Azimuth lens). If less stringent phase requirements are tolerable, then f and g can be reduced.

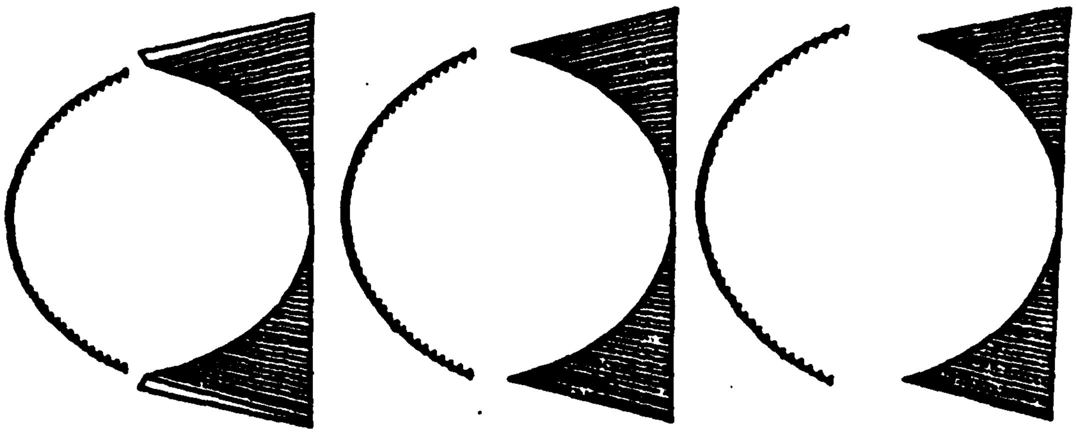
In designing the MLS lens antennas, it was discovered that internal reflections posed a much more significant problem than phase aberrations. The g parameter proved particularly critical in these considerations. A large value of g results in a large, highly curved focal arc (see Figure A-1c). A small value of g results in a highly curved lens surface (see Figure A-1a). These highly curved surfaces will tend to reflect much of the energy within the lens and cause beam shape distortion and higher sidelobe levels. It was empirically found that for $\alpha = 40°$, setting $g = 1.10$ caused both contours to have approximately the same curvature and minimized the internal reflections (see Figure A-1b). This value of g was used in the Basic Narrow and Small Community lenses.

The value of f affects the shape of the lens surface. A value of f that is too small results in a lens surface that begins to bend "backwards" (see Figure A-2). A value of f that is too large results in a large, unwieldy lens design (see Figure A-2c). It was decided to use a value of f that would minimize the antenna size without any "backward bending" of the lens surface (see Figure A-2b). The Basic Narrow and Small Community lenses have a focal length that is 57% of the aperture size.



a. $g = 1.05$ b. $g = 1.10$ (actual lens geometry) c. $g = 1.15$

FIGURE A-1. EFFECT OF VARYING g PARAMETER ON LENS GEOMETRY ($\alpha = 40°$, $f = 1.14$ m)



a. f = 1.05 m (51% of aperture)

b. f = 1.14 m (actual lens geometry)

c. f = 1.25 m (61% of aperture)

FIGURE A-2. EFFECT OF VARYING FOCAL LENGTH ON LENS GEOMETRY (α = 40°, g = 1.10)

A.3.2 Input Probe Spacing and Weighting Function

Through using BPOR2 to compute ideal input excitations, it was observed that each input probe had a characteristic phase associated with it independent of the beam shape and steering angle. It turned out that these phases corresponded to the path length differences between the various input probes and the lens center. By incorporating coaxial cables of varying lengths in series with each input probe to compensate for these path length differences, it was possible to decrease sidelobes, increase gain, and decrease beamwidth. These results were verified by BPORT and the cables were incorporated in the lens design. (Because Rotman excited only one horn at a time, it was not necessary for him to consider its phase.)

Through running BPORT, it was observed that excitation of a single input probe resulted in a nearly uniform aperture distribution and a far field pattern that is very nearly sin x/x (sinc (x)). It was proposed that the input probes should be spaced such that the sinc (x) beams generated by adjacent probes would be orthogonal. Beams generated by simultaneously exciting several probes with different amplitudes would be the superposition of several orthogonal sinc (x) beams of different amplitudes. A set of weights was also derived which would fine scan the beam in tenth beamwidth increments.

Considering the far field beams as the superposition of several sinc (x) beams clarified the significance of the input probe phases. If the input probe phases were not compensated for the path length differences, then the beams of adjacent sinc (x) patterns would not be in phase. Superposition of those out-of-phase beams would result in beam distortion. Because of the phase errors, the alternate sidelobes of adjacent

beams would not cancel each other and the sidelobe level would increase.

The input weighting function proposed has worked very well in the MLS lens antennas. These weights result in a nearly constant beam shape, theoretical sidelobe levels from -23 dB to -31 dB, theoretical beam gain changes of 0.06 dB over one cycle of 10 fine steps, and theoretical maximum beam pointing errors of 0.0134 of the probe spacing angle (approximately 0.02° error for the Basic Narrow lens). However, these weights are not necessarily the optimum weights for a Rotman lens antenna. For example, different weights may result in lower theoretical sidelobes at the expense of beam pointing accuracy. Future commutated lens designs may involve consideration of different weighting functions.

The orthogonal probe spacing has also worked very well. Orthogonality has the advantage that the input probe VSWR, excluding mutual coupling effects, is independent of the excitations on other input probes. However, there may be applications in which non-orthogonal spacing may be desirable. For example, closer spacing of the inputs and excitation of more than three inputs simultaneously may result in an improvement in beam pointing accuracy and sidelobe level. To do this, it would be necessary to determine a new weighting function.

A.4 CONCLUSIONS

The following recommendations are made for future designs of Rotman lens antennas:

a. Phase aberrations have not been a serious limitation on the performance of the MLS Rotman lenses. Therefore, f and g should be chosen to minimize the lens size and the internal reflections.

b. The phases of the input probes should be compensated for the path length differences between the probes

and the lens center. These phases seem to be optimum whether or not the probes are spaced orthogonally and regardless of the input weighting function.

c. Spacing the inputs orthogonally is probably optimum for most lens designs. However, it is possible that applications in which beam pointing accuracy or side-lobes are particularly critical may require non-orthogonal inputs.

d. The input weighting function proposed and used in the MLS lenses has worked very well. However, it is not necessarily the optimum weighting function for all lenses. Future Rotman lens designs may warrant consideration of other input weighting functions.

Appendix B

Reliability Test Plan

for

MLS Ground Equipment

Contract No.

DOT-FA72WA-2801

prepared by

The Bendix Corporation

Communications Division

Towson, Maryland 21204

November 1977

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B.1 SCOPE

This document describes the test program which will be followed to demonstrate that the MLS Ground Subsystem Equipment meets the mean-time-between-failure (MTBF) requirements specified in the Functional Requirements Specification. The plan has been prepared in accordance with MIL-STD-781.

B.2 REFERENCED DOCUMENTS

The following specifications and references form a part of this test plan to the extent specified herein:

a. MIL-STD-781B - Reliability Tests: Exponential Distribution
b. FAA-ER-700-07, Amendment 1, 2/25/75, revised 3/26/75, MLS Functional Requirements Specification
c. Statement of Work, Appendix (Reliability, Maintainability and Demonstration Plan)
d. 4041035 - Engineering Test Procedure, Basic Narrow Azimuth Subsystem (Bendix document)
e. 4041036 - Engineering Test Procedure, Basic Narrow Elevation Subsystem (Bendix document)

B.3 GENERAL TEST REQUIREMENTS

B.3.1 NUMERICAL RELIABILITY REQUIREMENTS

The specified MTBF for the MLS Ground Subsystem equipment is 3000 hours for each functional element (azimuth, elevation, back course, etc.) For the reliability demonstration, functional elements may be interchanged if they are comparable in their design and general parts populattion. The DME is excluded from the demonstration.

B.3.2 DESCRIPTION OF TEST SAMPLE

The prototype demonstration will be performed on Civil Basic systems built in compliance with FAA-G-2100. Since the azimuth angle equipment and the elevation angle equipment are reasonably comparable in both design and part population, the reliability tests will be performed on a common functional element basis using basic narrow azimuth and elevation equipment.

B.3.3 GENERAL TEST PLAN

The prototype reliability demonstration will be performed in two phases; factory and field.

B.3.3.1 FACTORY DEMONSTRATION

Two functional elements (azimuth and/or elevation) will be placed on test, prior to shipment, so that each may accumulate five days of continuous operation with no restarts should failures occur. Corrective action will be taken for each failure. Assessment of the validity of the corrective action will be accomplished by "off-line" test before continuation of the demonstration and ultimately through the results of the on-site field test.

Three additional elements will be tested using Test Plan XXV of MIL-STD-781B with no restarts. If failures occur, corrective action will be taken and verified by off-line test before continuation of the demonstration. This test plan is a short term (0.37 θ_o), fixed length, test with a 3/1 discrimination ratio and with consumer and producer risks of 30 percent.

A 48-hour burn-in period is allowed.

B.3.3.2 FIELD DEMONSTRATION

Demonstration tests in the field will involve all of the Basic Narrow elements fielded. The demonstration will be performed to Test Plan VI of MIL-STD-781B. This test plan is a short term (maximum -1.25 θ_o), variable length test with a discrimination ratio of 5 to 1 and with consumer and producer risks of 10 percent. Corrective action of failures will be in accordance with para. 5.7 of MIL-STD-781B.

B.3.4 TEST LEVELS

All factory reliability testing will be performed to Test Level A-1 of MIL-STD-781B to simulate the use environment. Test Level A-1 is a 25°C constant temperature test with no vibration or on/off cycling.

Field testing will be performed with each equipment installed and operating in its particular environmental shelter configuration.

B.3.5 Test Scheduling

The two-element factory test in paragraph B.3.3.1 will be performed on a 24-hour per day, 5-day per week basis until the specified test requirements are satisfied. The duration of this test will be 5 days of operation plus time lost for any corrective actions which may be required.

Factory tests to Test Plan XXV will be performed on a 24-hour per day, 7-day per week basis until the test requirements are met. The duration of this test is 1100 hours accumulated across three elements. Assuming equal distribution of time between the elements, the expected test duration is 16 days, plus time lost for the off-line verification of required corrective actions.

The field demonstration is a variable length test, depending on the number and frequency of failures, and can range from 1650 to 3750 accumulated hours, not including any time which may be required to perform retests. Assuming five elements, the expected duration of the field test would be about 5 weeks.

B.3.6 PERIODIC PERFORMANCE CHECKS

Performance checks will be made to determine equipment failures as defined in paragraph B.3.7. These checks will be made once every 24 hours during the normal working hours. For the factory tests, no measurements will be taken on weekends or holidays. Test instrumentation will be provided to the extent practical, to monitor and record the time of occurrence of equipment failures or test set-up malfunctions between performance checks.

The performance checks are given in paragraph B.5.3.

B.3.7 *DEFINITION OF FAILURE*

A failure during the reliability testing is defined as a malfunction in the equipment which causes a departure from the performance requirements to a degree which requires Facility shut down, i.e., an executive level equipment malfunction which fails to restart. Nuisance shut downs caused by operational considerations or external interference, rather than equipment malfunction, are not failures with regard to MTBF determination.

All failures will be classified with respect to dependency and relevancy in accordance with the following definitions:

1. Independent Failure: An independent failure is a failure which has no significant relationship to prior failures of other parts in the equipment. In the case of simultaneous related failures, at least one failure will be classified as independent.

2. Dependent Failure: A dependent failure is a failure which resulted either in part or in total from prior or simultaneous failures of other parts of the equipment or test set-up.
3. Relevant Failure: A relevant failure is a failure which does not fall into the nonrelevant classification. Relevant failures are chargeable to the equipment for determining accept/reject decisions.
4. Nonrelevant Failure: Any failure whose ultimate cause is due to accidental damage, mis-adjustments (operator), failure of another part (dependent), installation errors, operator errors, scheduled replacement, or failure of test equipment or facilities shall be classified as nonrelevant. Nonrelevant failures are not chargeable to the equipment and are not used for determination of accept/reject decisions.

B.3.8 DATA ANALYSIS

Compliance of the field test to the specification shall be determined by the accept/reject criteria given in Test Plan VI of MIL-STD-781B. Compliance will be reviewed after each equipment failure and when the accumulated test time reaches each accept decision point.

To synthesize the test data, accumulated hours and failures will be recorded in the Failure/Time Log and will be reviewed for compliance as noted above.

B.4.0 MODIFICATION OF UNITS FOR FACTORY TESTING

Each element (azimuth or elevation) will be operated with the equipment configured in an actual operating mode, and with power radiating. The far field monitor will be situated to receive the radiated signal so that the monitor subsystem is fully operational.

Each element which is used in factory testing will be operated independently. That is, elevation elements will not be synchronized to azimuth elements.

B.5.0 TEST PROCEDURES

B.5.1 PRE-TEST CHECKOUT

Prior to all system tests, every unit is subjected to individual tests verifying satisfactory operation of each unit and of the supporting test equipment and facilities and subsystem performance. During these checkouts all necessary adjustments, calibrations and attrition replacements are made. These standard checkouts will be performed on the reliability test samples, and verification of their satisfactory completion recorded on the operator's log by the test conductor. In addition to these tests, a checkout will be made to verify that subsystem interfaces have been properly connected.

B.5.2 BURN-IN

Since all units and the equipment group will have been performance tested prior to commencing the reliability test, as noted in B.5.1 above, no formal burn-in is presently planned for the factory demonstration.

If the field demonstration is to commence immediately following equipment installation, a period of 48 hours of failure-free operation, under normal operating conditions, shall be accrued prior to the start of formal reliability testing to verify the proper installation of the equipment. This burn-in will be applied at the element (azimuth/elevation) level. After completion of the burn-in a reference set of measurements will be taken to assure that all burn-in failures have been detected and are corrected before the start of the reliability test. This test will consist of Engineering Test Procedure 4041035 for the Azimuth Subsystem and 4041036 for the Elevation Subsystem.

B.5.3 PERIODIC PERFORMANCE CHECKS

Performance checks will be made to determine if equipment failures, as defined in paragraph B.3.7 have occurred. The checks will be made daily as outlined in paragraph B.3.6. Results of these tests will be recorded in the appropriate subsystem status log (Figure B.8-2 or B.8-3).

Since the subsystems are self-monitoring, the daily performance checks will consist of recording the subsystem status.

The performance checks will be performed as follows:

1. Record the appropriate unit identification data.
2. Perform the lamp test on the Local/Control and Maintenance Monitor Panels.
3. Verify the Presence of Morse Code. (Note: Loss of Morse Code does not constitute an executive malfunction. This data is recorded for completeness.)
4. Record Subsystem Status by indicating on the Monitor Panel chart the lamps which are lit.

   a. If the System Status executive function is normal, the check is completed.
   b. If the System Status executive function indicates a fault;
      1. Record the lamps which are lit, for reference.
      2. Place the Mode Switch on the Maintenance Monitor Panel in the maintenance position.
      3. Place the operate/test switch on the Local Control/Status panel in the test position.
      4. Operate the RESET switch on the Local Control/ Status Panel.
      5. Consult the chart recorder (if employed) to determine the time of occurrence of the outage.
   c. If the subsystem successfully Resets, return the positions to the operate mode and record the appropriate data on the data sheet.

d. If the subsystem fails to reset, record the information in the appropriate logs and begin diagnosis to determine if an equipment failure has occurred as noted paragraph B.6.

B.5.4 UNATTENDED OPERATION

The equipment normally operates in the unattended mode. At the completion of the performance check, the chart recorder (if employed) should be checked to be sure that sufficient paper and/or ink is provided for the next interval.

B.5.5 REQUIRED SUPPORT EQUIPMENT

The support equipment required for the initial checkout is outlined in Engineering Test Procedures 4041036 and 4041036.

The support equipment for use during reliability testing, includes:

Oscilloscope	Tektronix 545B or equivalent
Logic State Analyzer	HP 1600A or equivalent
RF Detector	HP 420 or equivalent
Dummy Load	Narda 376NM or equivalent
Chart Recorder	2 channel (for each Element under Test)

B.6 FAILURE PROCEDURE

When a subsystem registers an executive fault which fails to reset, appropriate entries shall be noted in the General Test Log and the Subsystem Status Log. The first step in the diagnosis is to determine whether an equipment malfunction has occurred or whether the shut down is due to external causes (e.g. a truck parked near the test area disturbing the monitor pattern.)

If the shutdown is due to an equipment malfunction, appropriate entries shall be recorded in the failure/time log and troubleshooting procedures begun. The failed subsystem will be restored either by repair or replacement, whichever is appropriate.

If the failure involves a discrete part or module the procedures outlined in paragraph B.6.1 will be followed.

B.6.1 FAILURE REPORTING, ANALYSIS AND CORRECTIVE ACTION

If a malfunction involving a discrete part or module is revealed during a periodic check, it will be recorded on a defect tag whose format is shown in Figure B.8-7 and the necessary maintenance performed to restore system operation. Malfunctions causing system failure, as defined in B.3.7 will be entered in the failure/time log, Figure B.8-4. The failure will be investigated and the tagged failed part analyzed to discover its failure mode. Results of the analysis and an investigation of circuitry will be used in arriving at corrective action, consisting of a better part choice for the application or circuit redesign to improve performance. It should be noted that this corrective action will be applied to the system as defined in paragraph B.3.3. A description of each failure, its analysis, and recommended corrective action will be recorded in a failure analysis report, whose format is shown in Figures B.8-8 and B.8-9.

B.7 TERMINATION OF TESTS

The factory tests will be terminated upon the completion of the specified requirements. The two-element factory test in B.3.3.1 will be terminated when 120 hours of operation have been accumulated on each element, and correction action has been implemented for each failure.

The factory test To Test Plan XXV will be terminated when a total of 1110 hours have been accumulated and corrective action has been implemented for each failure.

The field test will continue until either an accept or reject decision is reached in accordance with paragraph B.3.8. If a reject decision is reached the following procedure will be initiated:

a. Testing will be halted.

b. The results of the analysis of the failed part causing the reject decision together with the failure reports on all pertinent preceding failures will be reviewed for the corrective action recommendations. Appropriate corrective actions will be undertaken with the concurrence of the procuring activity.

c. A retest will be performed.

B.8 TEST RECORDS

Continuous test records will be kept throughout each of the reliability demonstrations. The data that will be recorded include performance check data, test time, number of failure, test facility data, and failure analysis data.

B.8.1 GENERAL TEST LOG

The General Test Log will be used to provide a chronological record of all test activities and interruptions occuring during the test to both the test units and the test facilities. Figure B.8-1 gives a sample of the General Test Log.

B.8.2 SUBSYSTEM STATUS LOG

A Subsystem Status Log will be kept for each unit under test to provide a complete history of the equipment. In this log will be recorded all performance data, and running time meter readings. These logs are given in Figures B.8-2 and B.8-3.

B.8.3 FAILURE/TIME LOG

Figure B.8-4 shows the Failure/Time Log. This sheet provides a separate tabulation of all data necessary for reaching an cccept or reject decision. Entries will be made each time an apparent equipment failure occurs, and at the accumulation of the discrete test times associated with accept decision points.

B.8.4 FACILITIES AND CALIBRATION LOG

A log shall be kept of all test equipment in use at any time during the reliability test together with a record of calibration dates and the period of allowable use before recalibration. A sample of this log is given in Figure B.8-5.

B.8.5 EQUIPMENT FAILURE SUMMARY LOG

A summary log of equipment failures will be kept to provide a ready reference of all equipment failures along with the RTM readings required, to delete from accumulated test time the equipment operating time logged between the time of failure and the return of the restored equipment to test. Such invalid operating time includes time logged between the time of failure and the start of normal working hours, and time logged during failure verification, and equipment checkout. A sample log is given in Figure B.8-6.

B.8.6 FAILURE RECORDS

Figure B.8-7 shows the defect tag for the recording of information pertaining to malfunctions of discrete parts or modules.

Figures B.8-8 and B.8-9 give the failure report form which will be kept for all failures occurring during the reliability test. The first part of the report concerns equipment symptoms and data pertinent to the reliability test. The second part of the report is the analysis section, recording the ultimate cause of failure and corrective action recommendations.

General Test Log

Reliability Test

MLS Basic Narrow Ground Subsystem

Angle Elements

Entry No.	Date	Time	Remarks	Init.

Figure B.8-1

Azimuth Element
Subsystem Status Log

Element S/N ________ Data Sheet Page No. ________

Reference: General Test Log Entry No. _____ Tester ______________

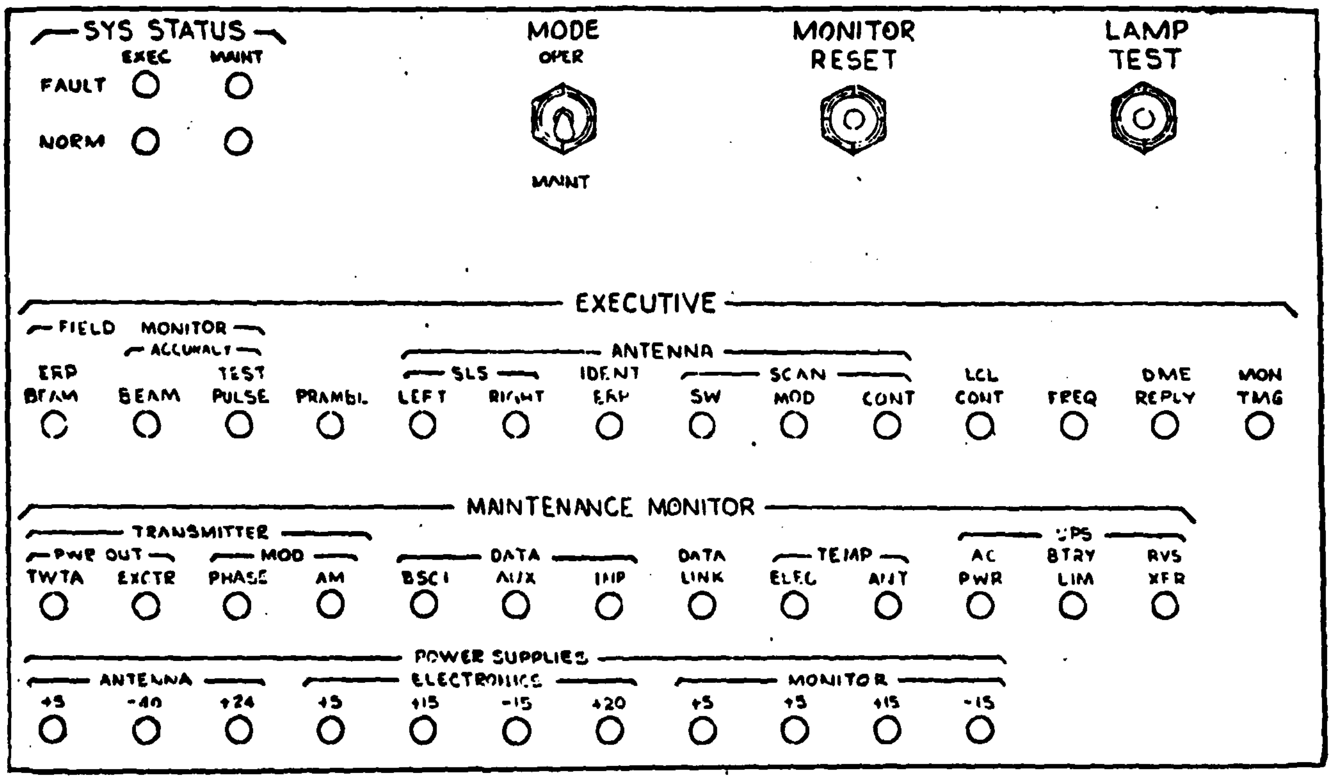
Date ____________ Time ________ RTM _________

Lamp Test: Local Control/Status Panel _____ OK; _____ LED OUT

Maintenance Monitor Panel _____ OK; _____ LED OUT

Morse Code: _____ OK; _____ FAULT

Monitor Panel Indications
(Check Lamps Which Are Lit - Before Reset)



Executive Status After Reset _____ Normal _____ Fault

Remarks: ____

____

____

Figure B.8-2

Elevation Element

Subsystem Status Log

Element S/N ________ Data Sheet Page No.________

Reference: General Test Log Entry No. _____ Tester______________

Date ____________ Time ________ RTM ________

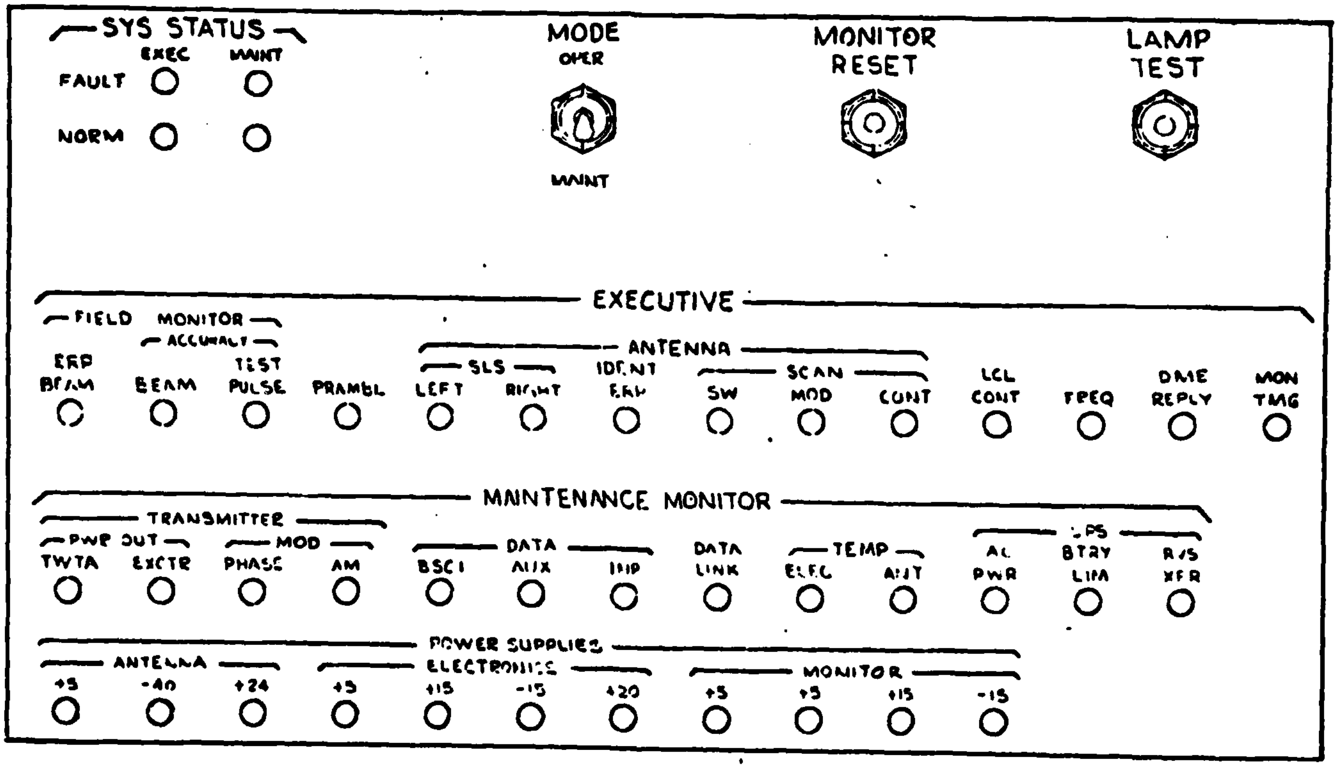
Lamp Test: Local Control/Status Panel _____ OK; _____ LED OUT

Maintenance Monitor Panel _____ OK; _____ LED OUT

Morse Code: _____ OK; _____ FAULT

Monitor Panel Indications

(Check Lamps Which Are Lit - Before Reset)



Executive Status After Reset _____ Normal _____ Fault

Remarks: ____

____

____

Figure B.8-3

Failure/Time Log
Reliability Test
MLS B/N Ground Subsystem
Angle Elements

Date & Time of Entry	Failed Element		Failure Report No.	Accum. Time on Failed Element	Test Status - All Elements			
	Identity	S/N			Cumul. Failures	Cumul. Hours	Normalized Test Time	Test Decision

Figure B.8-4

Facilities & Calibration Log

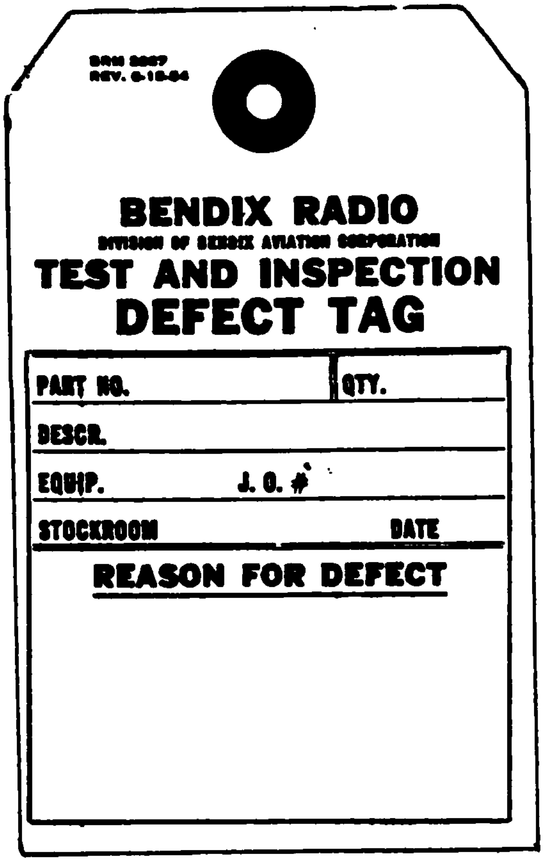
		Initial		Replacement or Recalibration Entry			
				1		2	
Item No.	Equipment and Model No.	Asset No. & Calib. Due Date	Date on Test	Asset No. & Calib. Due Date	Date on Test	Asset No. & Calib. Due Date	Date on Test

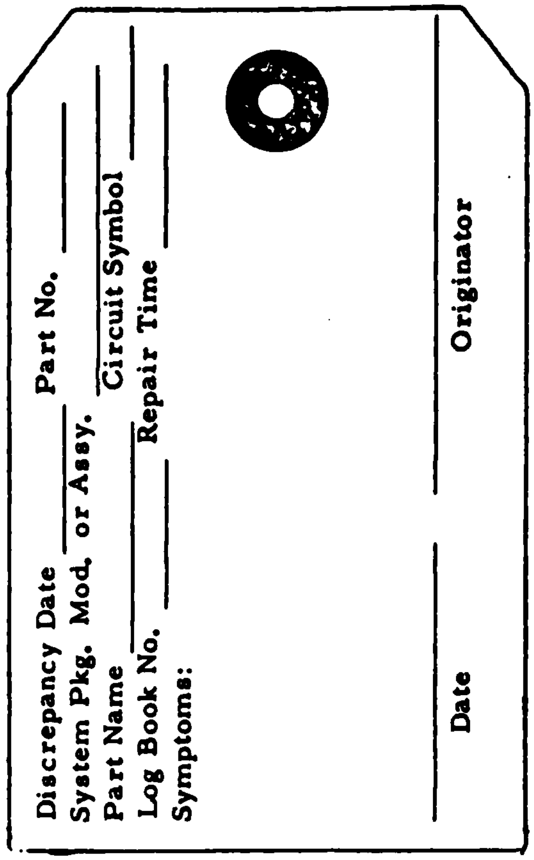
Figure B.8-5

Equipment Failure Summary Log

Line No.	Date & Time Removed	Date & Time Replaced	Failed Element		Element RTM	Failure Report No.	Failed Unit, Drawer, Assembly	Failed Board, Module, LRU	Remarks
			Description	S/N					

Figure B.8-6





1. Discrepancy Date - Enter here the date the part malfunction occurred.
2. Part No. - Enter here the Bendix number assigned to the part. This number will appear on the body of the part if large enough and will also appear in the assembly parts lists for the assembly the part is to be removed from.
3. System Pkg. MOd. or Assy. - Enter here the name of the assembly the part is to be removed from. This name will appear on the assembly name plate.
4. Part Name - Enter here the common name of the part removed, such as tube, transistor, resistor, etc.
5. Circuit Symbol - Enter here the circuit symbol that applies to the part that is to be removed. This symbol will appear on the assembly circuit schematic diagram and also on the assembly parts list for the assembly the part is to be removed from.
6. Log Book No. - Enter here the Log Book Number, page number, the entry line number in the Log Book that lists the defect being tagged. The equipment log book is maintained by the cognizant design engineer or test supervisor.
7. Repair Time - Enter here the time actually used to remove the part and to install a replacement part, in minutes. Do not count the time to obtain a replacement part, or to obtain tools or test equipment.
8. Symptoms - Enter here the most appropriate of the following symptoms; choose only one -
   - Circuit not operating
   - Circuit out of tolerance
   - Overheating
   - Circuit intermittent
   - Other

   If "Other" is entered, tell briefly how the malfunction affected circuit operating conditions.
9. Date - Enter here the date the defect tag is signed.
10. Originator - Enter here the name of the indvidual who filled out the defect tag.

Figure B.8-7

FAILURE ANALYSIS REPORT NO. ______

RELIABILITY TEST

MLS Ground Subsystem Sheet 1 of 2

Discrepancy Date_______________ Test Operator_______________________

Failed Element:____

Failed Unit/Drawer_____________ Serial No.__________________________

Failed Board___________________ Serial No.__________________________

Operator's Log ____ Line No. ____ Test Data Log ____ Line No. ____

Unit Accum. Operating Time____ Troubleshooting Time____

Replacement Time_____

Associated Defects (Log, Page, Line)________________________________

____

Failure Symptoms:

Diagnostic Tests:

Corrective Action to Repair Equipment:

Equipment Analysis by: ________________________________

Figure B.8-8

RELIABILITY LABORATORY ANALYSIS REPORT

NO. ______________

Bendix Communications Division

PAGE ____ OF ____

COMPONENT/PART NAME PER GENERIC CODE	Program	Requester	Request No.			
	Equipment S/N	Next Assy. Name		Day	Mo.	Yr.
LOG BOOK ______ P. ______ P. ______ BY ______	Failure Site/Date	Next Assy. P/N	Request			
OBJECTIVE/PURPOSE/SYMPTOM	TDRR No.	Assy. Operate Time	Test Compl.			
			Report Compl.			
	Ckt. Symbol	Test Type, etc.				

THIS TEST (SUPERSEDES) (SUPPLEMENTS) REPORT(S) NO:

Item	Part Type, Size, Rating, Lot, etc.	Vendor and H4 Code	Vendor P/N & Date Code	Ind./Govt. Std. No.	Qty.
1					
2					

	BCD SPECS/DWGS, ETC.		MIL SPECS/STD. ETC.		VENDOR, OTHER SPECS
A		D		G	
B		E		H	
C		F		I	

Item	Test or Environment	Per Spec	Spec. Paragraph/ Method/Condition	Test Levels, Duration, Details	No. Test	No. Fail

SUMMARY OF REPORT, RECOMMENDATIONS, CORRECTIVE ACTIONS

DISTRIBUTION:

Vendor Notified	Lab Approval	Program Approval

RELAB 1A: 1-77

Figure B.8-9

Appendix C

RELIABILITY, MAINTAINABILITY, HUMAN FACTORS AND SAFETY REPORT

Contract No.
DOT FA72WA-2801

Prepared by

The Bendix Corporation
Communications Division
Towson, Maryland 21204

November 1977

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RELIABILITY, MAINTAINABILITY, HUMAN FACTORS AND SAFETY REPORT

C.1 INTRODUCTION

This document is a final Reliability, Maintainability, Human Factors, and Safety Report covering results of analysis efforts on the Basic Narrow and Small Community Ground Equipment during Phase III of the MLS Program.

C.2 REQUIREMENTS

FAA-ER-700-07 specifies a mean-time-between-failures (MTBF) of 3000 hours for each of the Azimuth, Elevation, and DME functions, with a total system MTBF of 1,000 hours for the Basic Narrow Ground Equipment. Since the specification was prepared, the decision to utilize a commercially available DME has deleted this equipment from the reliability specification. Therefore, the system MTBF requirement for the Basic Narrow Azimuth and Elevation functions of the Ground Equipment is 1,500 hours,

The maintainability requirement is a mean-time-to-repair (MTTR) of 0.5 hours.

C.3 ANALYSIS RESULTS

C.3.1 RELIABILITY ANALYSIS

The reliability predictions for the Ground Equipment were performed in accordance with the procedures in MIL-STD-756A and using the prediction data in MIL-HDBK-217B as the primary source for failure rates. Failure rates of SMA connectors for semi-rigid cable were derived from field data obtained during the last phase.

C.3.1.1 Environmental Factors

Fixed ground environmental factors were used at the expected operating ambient temperature of 25°C. Temperature rises of from 0° to 10°C were applied based on the location in the cabinet rack. These temperature rises were added to the

ambient temperature in performing the prediction. That is, for an assembly with a $10^{\circ}C$ internal rise, the prediction was made using $35^{\circ}C$ to enter the part failure rate tables of MIL-HDBK-217B.

C.3.1.2 Quality Factors

For the Basic Narrow Configuration, the quality factors used represent the actual parts complement supplied in the Phase III Basic Narrow hardware. Essentially, FAA-G-2100 parts were assumed, the MIL-HDBK-217B factors being military specification with high-rel quality factors for M level parts. For integrated circuits, B1 level quality factors were used, and for discrete semiconductors JAN level factors were used.

For the Small Community Configuration, lower quality level factors were used to represent a more commercial configuration. Generally, nonhigh reliability passive parts were assumed and "C" level quality was assumed for the integrated circuits. The quality level for discrete semiconductors was generally assumed to be JAN.

C.3.1.3 Detailed Reliability Analysis Results

C.3.1.3.1 Basic Narrow Configuration - The results of the reliability prediction for the Basic Narrow Configuration yield an MTBF of 4,580 hours for the active azimuth equipment and 5,570 hours for the active elevation equipment. The MTBF's predicted for the executive monitoring are 7,760 hours for the azimuth monitoring and 8,840 hours for the elevation monitoring.

The combined MTBF for the system functions and executive monitoring are: azimuth - 2,880, elevation 3,420. These figures yield a total system MTBF of 1,560 hours.

Paragraph 1.2 of the Appendix to the Functional Requirements Specification (FAA-ER-700-07) implies that the monitoring functions should be at least 10 times more reliable than the equipment being monitored. This requirement further

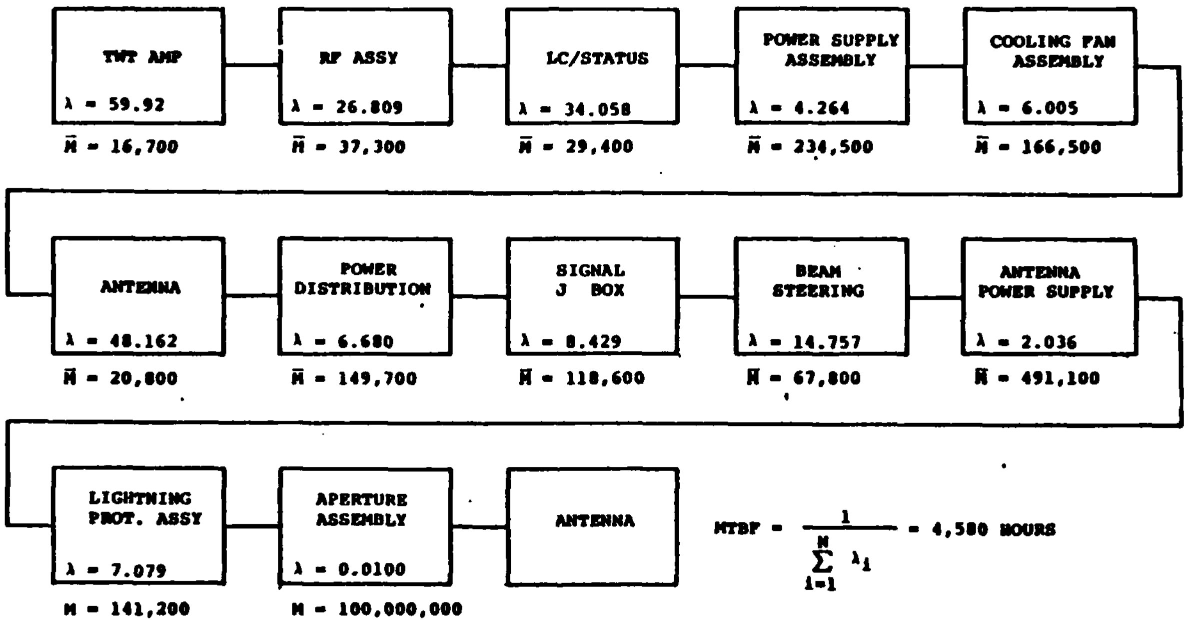
implies a monitor which is of very simple complexity to achieve an MTBF in the order of 30,000 hours. The integrity section (paragraph 11.0) of the same specification requires monitoring with sophistication sufficient to validate correctness of operation for all variations of the ground facility, instantaneous status changes, two-step monitoring/alarm and communication of status changes. The hardware complexity required to meet the integrity and monitoring specifications is not consistent with the simplicity implied in the statement that the monitoring should be 10 times more reliable than the system.

The approach, therefore, has been to simplify the monitoring to the maximum extent deemed appropriate for meeting the integrity requirements, and designing this required monitoring for high reliability. The individual items comprising the executive monitor are each highly reliable. However, the number of different functions which must be monitored to ensure maximum integrity precludes a simplified monitor approach.

In addition to the executive monitoring, maintenance monitoring is provided to aid in isolating failures to the faulty LRU. This maintenance monitoring is not included in the model since it has no effect on system operation and performs no executive or downgrading function. The MTBF's of the maintenance monitoring was calculated, however, for inclusion in the calculations for average number of maintenance actions required. The maintenance monitor MTBF's are 19,070 hours for azimuth and 20,870 hours for elevation.

Figures C.1 thru C.4 show the reliability models for the Basic Narrow Configuration. Figures C.5 thru C.8 contain the computer output summaries of the reliability prediction. The prediction details, showing the part level failure rates are too voluminous for inclusion in this document. They are on file at Bendix and will be made available for customer review upon request.

RM-RPT-001



$$MTBF = \frac{1}{\sum_{i=1}^{N} \lambda_i} = 4,580 \text{ HOURS}$$

FIGURE C.1. BASIC NARROW AZ ACTIVE RELIABILITY MODEL

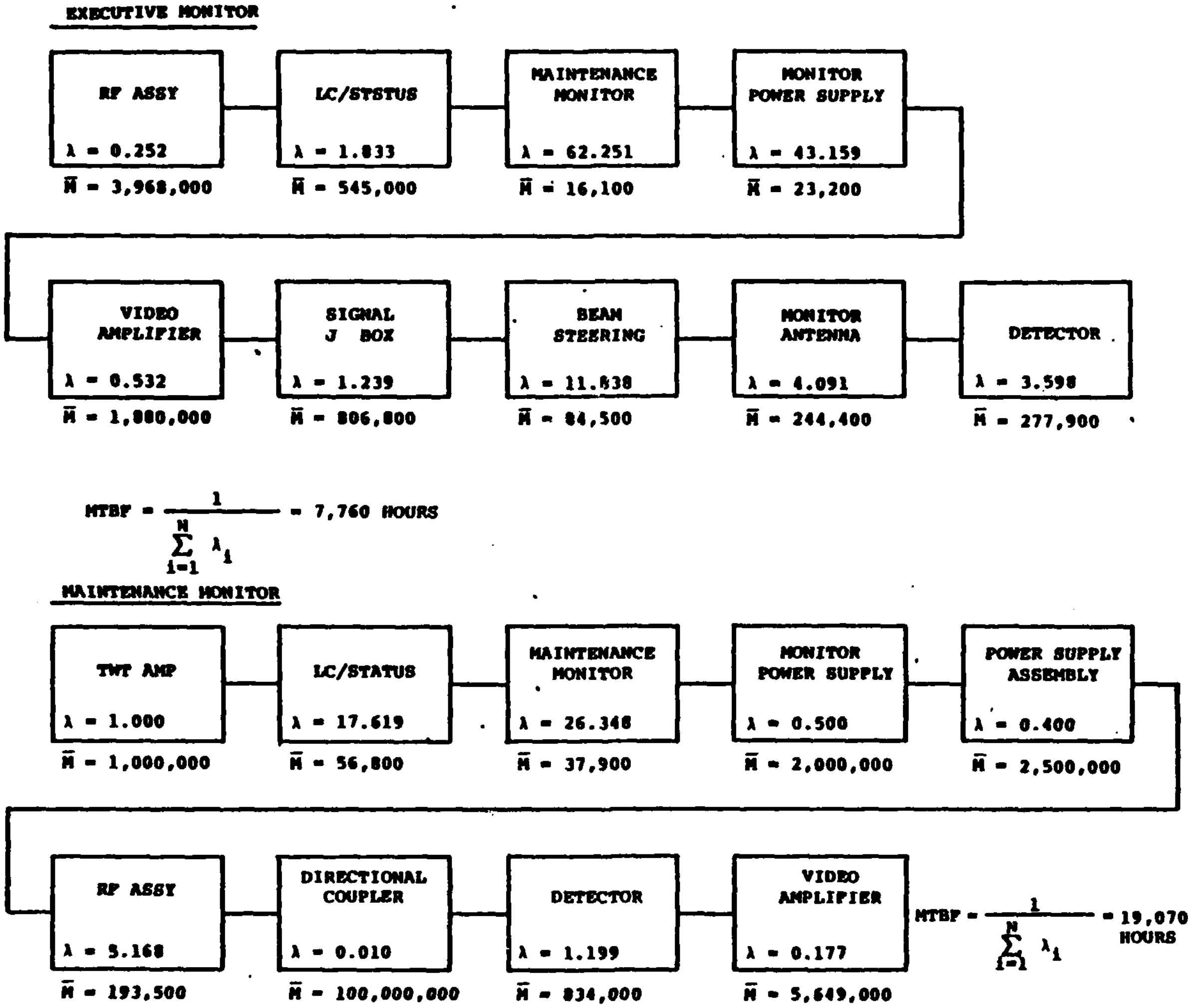


FIGURE C.2. BASIC NARROW AZ MONITOR RELIABILITY MODELS

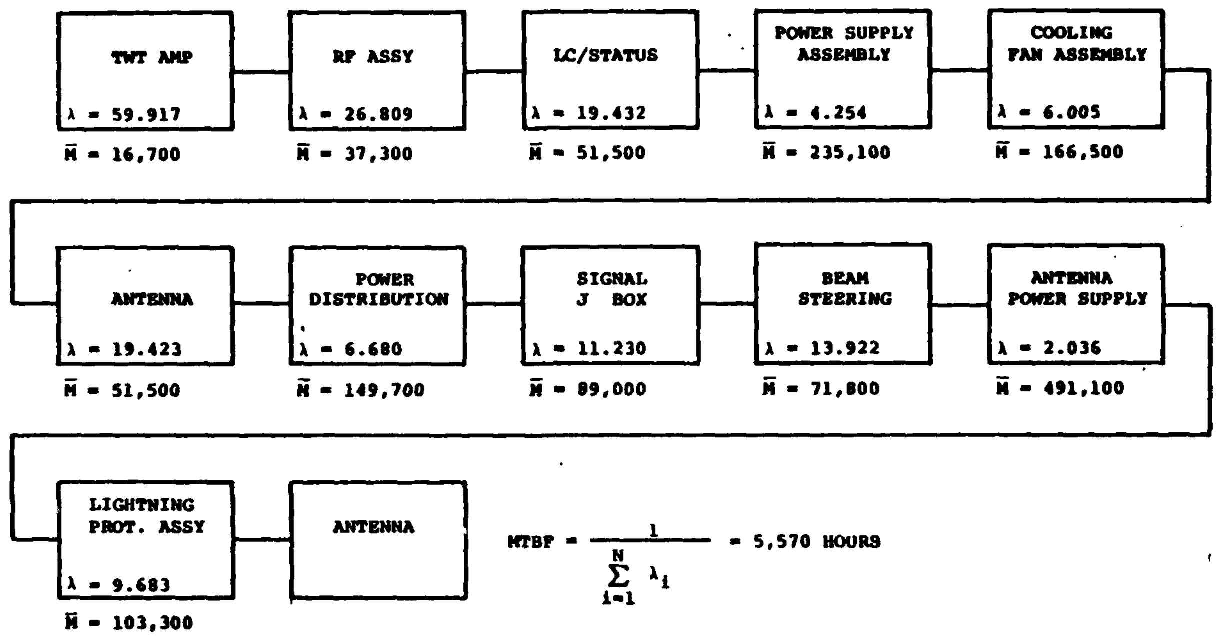


FIGURE C.3. BASIC NARROW EL ACTIVE RELIABILITY MODEL

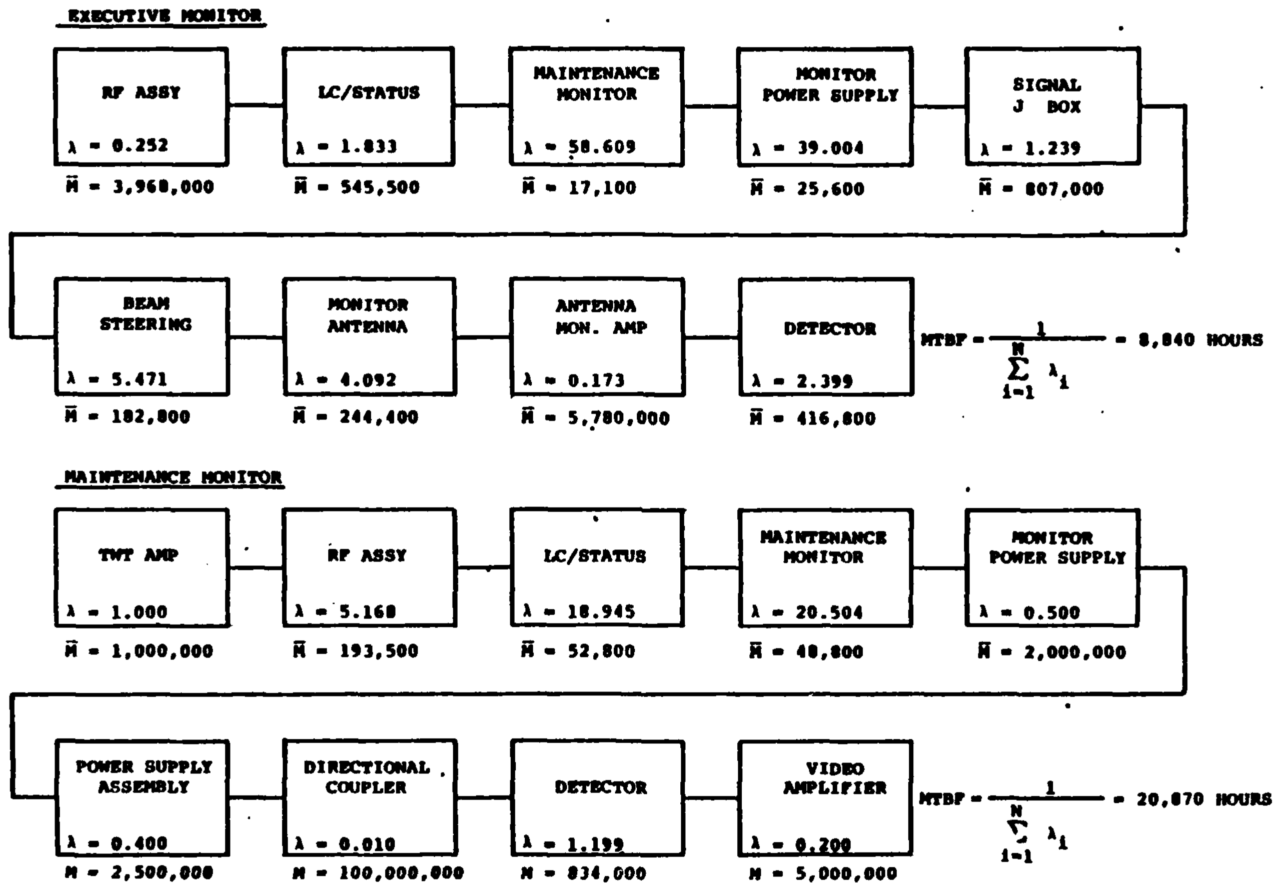


FIGURE C.4. BASIC NARROW EL MONITOR RELIABILITY MODELS

ASSEMBLY	SUBASSEMBLY	BOARD		(F.R.1)
ACTIVE EQUIP	TWT AMP A1A1A1	CHASSIS	(Q= 1)	4.03096
ACTIVE EQUIP	TWT AMP A1A1A1	PCB	(Q= 1)	4.26836
ACTIVE EQUIP	TWT AMP A1A1A1	H/V BOX	(Q= 1)	1.59270
ACTIVE EQUIP	TWT AMP A1A1A1	RF COMPONENTS	(Q= 1)	50.02470
ACTIVE EQUIP	RF ASSY A1A1A2		(Q= 1)	1.84141
ACTIVE EQUIP	RF ASSY A1A1A2	EXCITER A1A1A2A1	(Q= 1)	11.64571
ACTIVE EQUIP	RF ASSY A1A1A2	DPSK ASSY A1A1A2A2	(Q= 1)	2.67856
ACTIVE EQUIP	RF ASSY A1A1A2	AMP MOD A1A1A2A3	(Q= 1)	9.02338
ACTIVE EQUIP	RF ASSY A1A1A2	ISOLATOR P/O A1A1A2	(Q= 1)	0.76745
ACTIVE EQUIP	RF ASSY A1A1A2	ATTEN,VAR P/O A1A1A2	(Q= 1)	0.85252
ACTIVE EQUIP	LC/STATUS A1A1A3		(Q= 1)	6.79174
ACTIVE EQUIP	LC/STATUS A1A1A3	SYST SYNC A1A1A3A3	(Q= 1)	0.65755
ACTIVE EQUIP	LC/STATUS A1A1A3	DATA LINK A1A1A3A4	(Q= 1)	1.83593
ACTIVE EQUIP	LC/STATUS A1A1A3	DAT LK AUXA1A1A3A6	(Q= 1)	1.76248
ACTIVE EQUIP	LC/STATUS A1A1A3	VAR AUX A1A1A3A10	(Q= 1)	1.70685
ACTIVE EQUIP	LC/STATUS A1A1A3	FIX AUX 2 A1A1A3A11	(Q= 1)	2.12219
ACTIVE EQUIP	LC/STATUS A1A1A3	FIX AUX 1 A1A1A3A12	(Q= 1)	2.12219
ACTIVE EQUIP	LC/STATUS A1A1A3	AUX DS/WV A1A1A3A13	(Q= 1)	1.31403
ACTIVE EQUIP	LC/STATUS A1A1A3	AU/AD/PAR A1A1A3A14	(Q= 1)	1.60242
ACTIVE EQUIP	LC/STATUS A1A1A3	MORSE COD A1A1A3A15	(Q= 1)	1.36476
ACTIVE EQUIP	LC/STATUS A1A1A3	ID/BD/DPS A1A1A3A16	(Q= 1)	1.65630
ACTIVE EQUIP	LC/STATUS A1A1A3	SYS TIM GEA1A1A3A17	(Q= 1)	2.13297
ACTIVE EQUIP	LC/STATUS A1A1A3	TIM CNTRL A1A1A3A18	(Q= 1)	5.54339
ACTIVE EQUIP	LC/STATUS A1A1A3	10 MHZ DR A1A1A3A19	(Q= 1)	0.05236
ACTIVE EQUIP	LC/STATUS A1A1A3	10 MHZ OSCA1A1A3Y1	(Q= 1)	3.39331
ACTIVE EQUIP	PS ASSY A1A1A6		(Q= 1)	1.61052
ACTIVE EQUIP	PS ASSY A1A1A6	20V P.SUPPA1A1A6PS1	(Q= 1)	0.75369
ACTIVE EQUIP	PS ASSY A1A1A6	15V P.SUPPA1A1A6PS2	(Q= 1)	1.29561
ACTIVE EQUIP	PS ASSY A1A1A6	5V P.SUPP A1A1A6PS3	(Q= 1)	0.60455
ACTIVE EQUIP	COOL FAN A1A1B1		(Q= 1)	6.00519
ACTIVE EQUIP	ANTENNA	SCAN SWIT A2S1-16	(Q=16)	38.10316
ACTIVE EQUIP	ANTENNA	SCAN MOD. A2A2	(Q= 1)	8.84140
ACTIVE EQUIP	ANTENNA	ANT.SEL.SWA1A1S1	(Q= 1)	1.21734
ACTIVE EQUIP	PWR.DIST A1N1		(Q= 1)	6.68013
ACTIVE EQUIP	SIG J BOX A1N2	LPB NO1	(Q= 1)	1.79791
ACTIVE EQUIP	SIG J BOX A1N2	LPB NO1	(Q= 1)	1.79791
ACTIVE EQUIP	SIG J BOX A1N2	LPB NO4	(Q= 1)	4.83352
ACTIVE EQUIP	BM STEER. A2A1		(Q= 1)	4.04673
ACTIVE EQUIP	BM STEER. A2A1	SCAN CNTR A2A1A1	(Q= 1)	2.51020
ACTIVE EQUIP	BM STEER. A2A1	SC.CN.COMPA2A1A2	(Q= 1)	1.94641
ACTIVE EQUIP	BM STEER. A2A1	SC.SW.DRIVA2A1A4	(Q= 1)	1.53663
ACTIVE EQUIP	BM STEER. A2A1	SS DR.INT.A2A1A5	(Q= 1)	2.07627
ACTIVE EQUIP	BM STEER. A2A1	10 MHZ OSCA2A1Y1	(Q= 1)	2.64071
ACTIVE EQUIP	ANT.PS.ASYA2A4		(Q= 1)	0.08207
ACTIVE EQUIP	ANT.PS.ASYA2A4	5V P.SUPP A2A4PS1	(Q= 1)	0.60696
ACTIVE EQUIP	ANT.PS.ASYA2A4	24V P.SUPPA2A4PS2	(Q= 1)	0.62664
ACTIVE EQUIP	ANT.PS.ASYA2A4	40V P.SUPPA2A4PS3	(Q= 1)	0.72043
ACTIVE EQUIP	L.P.ASSY A2A5	LPB NO1 A2A5A1	(Q= 1)	1.79791
ACTIVE EQUIP	L.P.ASSY A2A5	LPB NO5 A2A5A2	(Q= 1)	5.28136
ACTIVE EQUIP	APPER ASY A2E1		(Q= 1)	0.01000

OVERALL FAILURE RATES FOR THIS EQUIPMENT 218.20727

OVERALL MTBF FOR THIS EQUIPMENT 4582.79981

FIGURE C.5. BASIC NARROW AZ ACTIVE RELIABILITY PREDICTIONS

ASSEMBLY	SUBASSEMBLY	BOARD	(F.R.1)
EXEC MON EQUIP	RF ASSY A1A1A2	DET AMP A1A1A2AR1 (Q= 1)	0.25219
EXEC MON EQUIP	LC/STATUS A1A1A3	SEQ/TIMER A1A1A3A2 (Q= 1)	1.83305
EXEC MON EQUIP	MAINT.MON A1A1A4	EXEC INT. P/O A1A1A4(Q= 4)	9.20685
EXEC MON EQUIP	MAINT.MON A1A1A4	MON CNTRL A1A1A4A6 (Q= 1)	1.11803
EXEC MON EQUIP	MAINT.MON A1A1A4	MORSE COD A1A1A4A7 (Q= 1)	1.57129
EXEC MON EQUIP	MAINT.MON A1A1A4	DPSK DECO A1A1A4A8 (Q= 1)	1.06563
EXEC MON EQUIP	MAINT.MON A1A1A4	DPSK DECI A1A1A4A9 (Q= 1)	3.05165
EXEC MON EQUIP	MAINT.MON A1A1A4	DISC DATA A1A1A4A10 (Q= 1)	0.97163
EXEC MON EQUIP	MAINT.MON A1A1A4	RECLOCK DRA1A1A4A23 (Q= 1)	0.53102
EXEC MON EQUIP	MAINT.MON A1A1A4	ID/BD/DPS A1A1A4A25 (Q= 1)	1.65630
EXEC MON EQUIP	MAINT.MON A1A1A4	SYS TIM GEA1A1A4A26 (Q= 1)	2.34612
EXEC MON EQUIP	MAINT.MON A1A1A4	MON TIM A1A1A4A28 (Q= 1)	1.82542
EXEC MON EQUIP	MAINT.MON A1A1A4	SCAN TIM A1A1A4A29 (Q= 1)	16.59309
EXEC MON EQUIP	MAINT.MON A1A1A4	AN.COM.#1 A1A1A4A30 (Q= 1)	2.35163
EXEC MON EQUIP	MAINT.MON A1A1A4	DET/COMP A1A1A4A31 (Q= 1)	0.89428
EXEC MON EQUIP	MAINT.MON A1A1A4	BE ACC CO A1A1A4A32 (Q= 1)	5.18528
EXEC MON EQUIP	MAINT.MON A1A1A4	DIG COMP. A1A1A4A33 (Q= 1)	10.43492
EXEC MON EQUIP	MAINT.MON A1A1A4	FREQ MON. A1A1A4A34 (Q= 1)	3.44774
EXEC MON EQUIP	MON PS ASYA1A1A5	(Q= 1)	3.13538
EXEC MON EQUIP	MON PS ASYA1A1A5	C BAND LO A1A1A5A1A1(Q= 1)	11.64572
EXEC MON EQUIP	MON PS ASYA1A1A5	RF MODULE A1A1A5A1A2(Q= 1)	19.97954
EXEC MON EQUIP	MON PS ASYA1A1A5	REG/BUFFERA1A1A5A1A3(Q= 1)	0.87728
EXEC MON EQUIP	MON PS ASYA1A1A5	MIXER A1A1A5A1Z1(Q= 1)	0.90727
EXEC MON EQUIP	MON PS ASYA1A1A5	PWR DIV. A1A1A5A1Z2(Q= 1)	1.17393
EXEC MON EQUIP	MON PS ASYA1A1A5	50 OHM TERA1A1A5AT1 (Q= 1)	2.94888
EXEC MON EQUIP	MON PS ASYA1A1A5	5V P.SUPP A1A1A5P1/2(Q= 2)	1.19760
EXEC MON EQUIP	MON PS ASYA1A1A5	15V P.SUP A1A1A5PS3 (Q= 1)	1.29357
EXEC MON EQUIP	VIDEO AMP P/O A1AR	(Q= 3)	0.53227
EXEC MON EQUIP	DETECTOR P/O A1CR	(Q= 3)	3.59824
EXEC MON EQUIP	SIG J BOX A1N2	LPB NO2 (Q= 1)	1.23940
EXEC MON EQUIP	BM STEER A2A1	SC.CN.MON.A2A1A3 (Q= 1)	2.66057
EXEC MON EQUIP	BM STEER A2A1	SS MONITORA2A1A6 (Q= 1)	2.81032
EXEC MON EQUIP	BM STEER A2A1	SS MON EXPA2A1A7/A8 (Q= 2)	4.33291
EXEC MON EQUIP	BM STEER A2A1	SS MON INTA2A1A9 (Q= 1)	2.03421
EXEC MON EQUIP	MON ANT A3	PWR DIST A3N1 (Q= 1)	0.26955
EXEC MON EQUIP	MON ANT A3	LPB NO 3 (Q= 1)	0.91843
EXEC MON EQUIP	MON ANT A3	VIDEO AMP A3N2AR1 (Q= 1)	0.23044
EXEC MON EQUIP	MON ANT A3	RF DET A3N2CR1 (Q= 1)	1.10134
EXEC MON EQUIP	MON ANT A3	BAND FILT A3N2FL1 (Q= 1)	0.67870
EXEC MON EQUIP	MON ANT A3	PWR DIV A3N2Z1 (Q= 1)	0.94305
MAINT MON EQUIP	TWT AMP A1A1A1	CHASSIS (Q= 1)	1.00000
MAINT MON EQUIP	RF ASSY A1A1A2	TERMIN. P/O A1A1A2(Q= 3)	2.55757
MAINT MON EQUIP	RF ASSY A1A1A2	DETECTOR P/O A1A1A2(Q= 2)	2.61000
MAINT MON EQUIP	LC/STATUS A1A1A3	(Q= 1)	13.75825
MAINT MON EQUIP	LC/STATUS A1A1A3	LT DR/ALM A1A1A3A1 (Q= 1)	1.86031
MAINT MON EQUIP	LC/STATUS A1A1A3	LC/ST.IND.A1A1A3A20 (Q= 1)	1.99999
MAINT MON EQUIP	MAINT.MON A1A1A4	(Q= 1)	5.09181
MAINT MON EQUIP	MAINT.MON A1A1A4	MAINT INT.P/O A1A1A4(Q= 3)	6.59881
MAINT MON EQUIP	MAINT.MON A1A1A4	MAIN.MO.INA1A1A4A35 (Q= 1)	8.39999
MAINT MON EQUIP	MAINT.MON A1A1A4	AN.COM.#3 A1A1A4A11 (Q= 1)	2.36427
MAINT MON EQUIP	MAINT.MON A1A1A4	AN.COM.#2 A1A1A4A13 (Q= 1)	2.28655
MAINT MON EQUIP	MAINT.MON A1A1A4	AU/AD/PAR A1A1A4A24 (Q= 1)	1.61664
MAINT MON EQUIP	MON PS ASYA1A1A5	(Q= 1)	0.50000
MAINT MON EQUIP	PS ASSY A1A1A6	(Q= 1)	0.40000
MAINT MON EQUIP	DIR CPLR A1A1DC1	(Q= 1)	0.01000
MAINT MON EQUIP	DETECTOR A1A1CR1	(Q= 1)	1.19941
MAINT MON EQUIP	VIDEO AMP A1A1AR1	(Q= 1)	0.17742

OVERALL FAILURE RATES FOR THIS EQUIPMENT 181.21548

OVERALL MTBF FOR THIS EQUIPMENT 5518.29395

FIGURE C.6. BASIC NARROW AZ MONITOR RELIABILITY PREDICTIONS

ASSEMBLY	SUBASSEMBLY	BOARD		(F.R.1)
ACTIVE EQUIP	TWT AMP A1A1A1	CHASSIS	(Q= 1)	4.03096
ACTIVE EQUIP	TWT AMP A1A1A1	PCB	(Q= 1)	4.26836
ACTIVE EQUIP	TWT AMP A1A1A1	H/V BOX	(Q= 1)	1.59270
ACTIVE EQUIP	TWT AMP A1A1A1	RF COMPONENTS	(Q= 1)	50.02470
ACTIVE EQUIP	RF ASSY A1A1A2		(Q= 1)	1.84141
ACTIVE EQUIP	RF ASSY A1A1A2	EXCITER A1A1A2A1	(Q= 1)	11.64571
ACTIVE EQUIP	RF ASSY A1A1A2	DPSK ASSY A1A1A2A2	(Q= 1)	2.67856
ACTIVE EQUIP	RF ASSY A1A1A2	AMP MOD A1A1A2A3	(Q= 1)	9.02338
ACTIVE EQUIP	RF ASSY A1A1A2	ISOLATOR P/O A1A1A2	(Q= 1)	0.76745
ACTIVE EQUIP	RF ASSY A1A1A2	ATTEN,VAR P/O A1A1A2	(Q= 1)	0.85252
ACTIVE EQUIP	LC/STATUS A1A1A3		(Q= 1)	1.43000
ACTIVE EQUIP	LC/STATUS A1A1A3	SYST SYNC A1A1A3A3	(Q= 1)	1.58504
ACTIVE EQUIP	LC/STATUS A1A1A3	DATA LINK A1A1A3A4	(Q= 1)	1.83593
ACTIVE EQUIP	LC/STATUS A1A1A3	ID/BD/DPS A1A1A3A16	(Q= 1)	1.65630
ACTIVE EQUIP	LC/STATUS A1A1A3	SYS TIM GEA1A1A3A17	(Q= 1)	2.12854
ACTIVE EQUIP	LC/STATUS A1A1A3	TIM CNTRL A1A1A3A18	(Q= 1)	7.35032
ACTIVE EQUIP	LC/STATUS A1A1A3	10 MHZ DR A1A1A3A19	(Q= 1)	0.05236
ACTIVE EQUIP	LC/STATUS A1A1A3	10 MHZ OSCA1A1A3Y1	(Q= 1)	3.39331
ACTIVE EQUIP	PS ASSY A1A1A6		(Q= 1)	1.60052
ACTIVE EQUIP	PS ASSY A1A1A6	20V P.SUPPA1A1A6PS1	(Q= 1)	0.75369
ACTIVE EQUIP	PS ASSY A1A1A6	15V P.SUPPA1A1A6PS2	(Q= 1)	1.29561
ACTIVE EQUIP	PS ASSY A1A1A6	5V P.SUPP A1A1A6PS3	(Q= 1)	0.60455
ACTIVE EQUIP	COOL FAN A1A1B1		(Q= 1)	6.00519
ACTIVE EQUIP	ANTENNA	SCAN SWIT A2S1-4	(Q= 4)	9.52579
ACTIVE EQUIP	ANTENNA	SCAN MOD. A2A2	(Q= 1)	8.84140
ACTIVE EQUIP	ANTENNA	ANT SEL SWA2S5	(Q= 1)	1.05603
ACTIVE EQUIP	PWR.DIST A1N1		(Q= 1)	6.68013
ACTIVE EQUIP	SIG J BOX A1N2	LPB NO1	(Q= 1)	1.85694
ACTIVE EQUIP	SIG J BOX A1N2	LPB NO1	(Q= 1)	2.99655
ACTIVE EQUIP	SIG J BOX A1N2	LPB NO2	(Q= 1)	1.42505
ACTIVE EQUIP	SIG J BOX A1N2	LPB NO4	(Q= 1)	4.33284
ACTIVE EQUIP	SIG J BOX A1N2	LPB NO1	(Q= 1)	0.61897
ACTIVE EQUIP	BM STEER. A2A1		(Q= 1)	6.82475
ACTIVE EQUIP	BM STEER. A2A1	SCAN CNTR A2A1A1	(Q= 1)	2.51020
ACTIVE EQUIP	BM STEER. A2A1	SC.CN.COMPA2A1A2	(Q= 1)	1.94641
ACTIVE EQUIP	BM STEER. A2A1	10 MHZ OSCA2A1Y1	(Q= 1)	2.64071
ACTIVE EQUIP	ANT.PS.ASYA2A4		(Q= 1)	0.08207
ACTIVE EQUIP	ANT.PS.ASYA2A4	5V P.SUPP A2A4PS1	(Q= 1)	0.60696
ACTIVE EQUIP	ANT.PS.ASYA2A4	24V P.SUPPA2A4PS2	(Q= 1)	0.62664
ACTIVE EQUIP	ANT.PS.ASYA2A4	40V P.SUPPA2A4PS3	(Q= 1)	0.72043
ACTIVE EQUIP	L.P.ASSY A2A5	LPB NO1 A2A5A1	(Q= 1)	3.09486
ACTIVE EQUIP	L.P.ASSY A2A5	LPB NO2 A2A5A2	(Q= 1)	1.31941
ACTIVE EQUIP	L.P.ASSY A2A5	LPB NO5 A2A5A3	(Q= 1)	5.26907

OVERALL FAILURE RATES FOR THIS EQUIPMENT 179.39212

OVERALL MTBF FOR THIS EQUIPMENT 5574.38184

FIGURE C.7. BASIC NARROW EL ACTIVE RELIABILITY PREDICTIONS

ASSEMBLY	SUBASSEMBLY	BOARD		(F.R.1)
EXEC MON EQUIP	RF ASSY A1A1A2	DET AMP A1A1A2AR1	(Q= 1)	0.25219
EXEC MON EQUIP	LC/STATUS A1A1A3	SEQ/TIMER A1A1A3A2	(Q= 1)	1.83305
EXEC MON EQUIP	MAINT.MON A1A1A4	EXEC INT. P/O A1A1A4	(Q= 3)	6.90514
EXEC MON EQUIR	MAINT.MON A1A1A4	MON CNTRL A1A1A4A6	(Q= 1)	1.11803
EXEC MON EQUIP	MAINT.MON A1A1A4	DPSK DECO A1A1A4A8	(Q= 1)	1.06563
EXEC MON EQUIP	MAINT.MON A1A1A4	DPSK DECI A1A1A4A9	(Q= 1)	3.05165
EXEC MON EQUIP	MAINT.MON A1A1A4	DISC DATA A1A1A4A10	(Q= 1)	0.97163
EXEC MON EQUIP	MAINT.MON A1A1A4	RECLOCK DRA1A1A4A23	(Q= 1)	0.53102
EXEC MON EQUIP	MAINT.MON A1A1A4	ID/BD/DPS A1A1A4A25	(Q= 1)	1.65630
EXEC MON EQUIP	MAINT.MON A1A1A4	SYS TIM GEA1A1A4A26	(Q= 1)	2.34612
EXEC MON EQUIP	MAINT.MON A1A1A4	MON TIM A1A1A4A28	(Q= 1)	1.82542
EXEC MON EQUIP	MAINT.MON A1A1A4	SCAN TIM A1A1A4A29	(Q= 1)	16.59309
EXEC MON EQUIP	MAINT.MON A1A1A4	AN.COM.#1 A1A1A4A30	(Q= 1)	2.35163
EXEC MON EQUIP	MAINT.MON A1A1A4	DET/COMP A1A1A4A31	(Q= 1)	0.89428
EXEC MON EQUIP	MAINT.MON A1A1A4	BE ACC CO A1A1A4A32	(Q= 1)	4.65752
EXEC MON EQUIP	MAINT.MON A1A1A4	DIG COMP. A1A1A4A33	(Q= 1)	10.43492
EXEC MON EQUIP	MAINT.MON A1A1A4	FREQ MON. A1A1A4A34	(Q= 1)	3.44774
EXEC MON EQUIP	MAINT.MON A1A1A4	TIMING REFA1A1A4A27	(Q= 1)	0.75968
EXEC MON EQUIP	MON PS ASYA1A1A5		(Q= 1)	3.10278
EXEC MON EQUIP	MON PS ASYA1A1A5	C BAND LO A1A1A5A1A1	(Q= 1)	11.64572
EXEC MON EQUIP	MON PS ASYA1A1A5	RF MODULE A1A1A5A1A2	(Q= 1)	19.97954
EXEC MON EQUIP	MON PS ASYA1A1A5	REG/BUFFERA1A1A5A1A3	(Q= 1)	0.87728
EXEC MON EQUIP	MON PS ASYA1A1A5	MIXER A1A1A5A1Z1	(Q= 1)	0.90727
EXEC MON EQUIP	MON PS ASYA1A1A5	5V P.SUPP A1A1A5P1/2	(Q= 2)	1.19760
EXEC MON EQUIP	MON PS ASYA1A1A5	15V P.SUP A1A1A5PS3	(Q= 1)	1.29357
EXEC MON EQUIP	SIG J BOX A1N2	LPB NO2	(Q= 1)	1.23940
EXEC MON EQUIP	BM STEER A2A1	SC.CN.MON.A2A1A3	(Q= 1)	2.66057
EXEC MON EQUIP	BM STEER A2A1	SS MONITORA2A1A4	(Q= 1)	2.81032
EXEC MON EQUIP	ANT MO AMPA2AR		(Q= 1)	0.17314
EXEC MON EQUIP	DETECTOR A2CR1-2		(Q= 2)	2.39882
EXEC MON EQUIP	MON ANT A3	PWR DIST A3N1	(Q= 1)	0.26955
EXEC MON EQUIP	MON ANT A3	LPB NO 3	(Q= 1)	0.91843
EXEC MON EQUIP	MON ANT A3	VIDEO AMP A3N2AR1	(Q= 1)	0.23044
EXEC MON EQUIP	MON ANT A3	RF DET A3N2CR1	(Q= 1)	1.10134
EXEC MON EQUIP	MON ANT A3	BAND FILT A3N2FL1	(Q= 1)	0.62870
EXEC MON EQUIP	MON ANT A3	PWR DIV A3N2Z1	(Q= 1)	0.94305
MAINT MON EQUIP	TWT AMP A1A1A1	CHASSIS	(Q= 1)	1.00000
MAINT MON EQUIP	RF ASSY A1A1A2	TERMIN P/O A1A1A2	(Q= 3)	2.55757
MAINT MON EQUIP	RF ASSY A1A1A2	DETECTOR P/O A1A1A2	(Q= 2)	2.61000
MAINT MON EQUIP	LC/STATUS A1A1A3		(Q= 1)	15.08483
MAINT MON EQUIP	LC/STATUS A1A1A3	LT DR/ALM A1A1A3A1	(Q= 1)	1.86031
MAINT MON EQUIP	LC/STATUS A1A1A3	LC/ST.IND.A1A1A3A20	(Q= 1)	1.99999
MAINT MON EQUIP	MAINT.MON A1A1A4		(Q= 1)	1.45689
MAINT MON EQUIP	MAINT.MON A1A1A4	MAINT INT.P/O A1A1A4	(Q= 3)	6.59881
MAINT MON EQUIP	MAINT.MON A1A1A4	MAIN.MO.INA1A1A4A35	(Q= 1)	7.80000
MAINT MON EQUIP	MAINT.MON A1A1A4	AN.COM.#3 A1A1A4A11	(Q= 1)	2.36420
MAINT MON EQUIP	MAINT.MON A1A1A4	AN.COM.#2 A1A1A4A13	(Q= 1)	2.28655
MAINT MON EQUIP	MON PS ASYA1A1A5		(Q= 1)	0.50000
MAINT MON EQUIP	PS ASSY A1A1A6		(Q= 1)	0.40000
MAINT MON EQUIP	DIR CPLR A1A1DC1		(Q= 1)	0.01000
MAINT MON EQUIP	DETECTOR A1A1CR1		(Q= 1)	1.19941
MAINT MON EQUIP	VIDEO AMP A1A1AR1		(Q= 1)	0.20009

OVERALL FAILURE RATES FOR THIS EQUIPMENT 160.99881

OVERALL MTBF FOR THIS EQUIPMENT 6211.22755

FIGURE C.8. BASIC NARROW EL MONITOR RELIABILITY PREDICTIONS

C.3.1.3.2 Small Community Configuration - The reliability prediction for the Small Community Configuration yields an MTBF of 4,350 hours for the active azimuth equipment and 4,470 hours for the active elevation equipment at 25°C. The MTBF's for the executive monitoring functions are 4,250 hours for azimuth and 5,070 hours for elevation. The maintenance monitor predictions are, azimuth - 11,300 hours, elevation - 12,620 hours. Figure C.9 thru C.12 give the reliability block diagrams for the Small Community Configuration. Figures C.13 thru C.16 show the computer summaries of the reliability prediction for this configuration. Further details of the prediction are maintained at Bendix and will be made available for customer review upon request.

The reliability prediction for the Small Community Configuration is based on a best commercial practice design. In making the prediction, the lowest quality levels of failure rates given in MIL-HDBK-217B were used for commercial parts since no other commercial data is readily available. In Bendix experience, the calculation resulting from this assumption represents a bottom limit of the MTBF that can be expected since the type of equipment being designed and built for MLS is not of the type that is typically construed as commercial design, and is, therefore, not accurately represented by this prediction assumption. Factors which invalidate the prediction technique for commercial grade parts include the fact that the MLS equipment is designed to meet the full range of operational and environmental conditions specified. The MLS is not a high volume commercial production operation in which equipment is operated for only a few brief minutes, but in fact, the equipment will be fully tested to the same general criteria as the Basic Narrow. The parts used are not of the cheapest commercial grade available, but rather are high grade commercial, computer grade and, in many instances, MIL-spec parts. Additionally, Bendix has imposed its in-house "best commercial practice" specifications on vendors

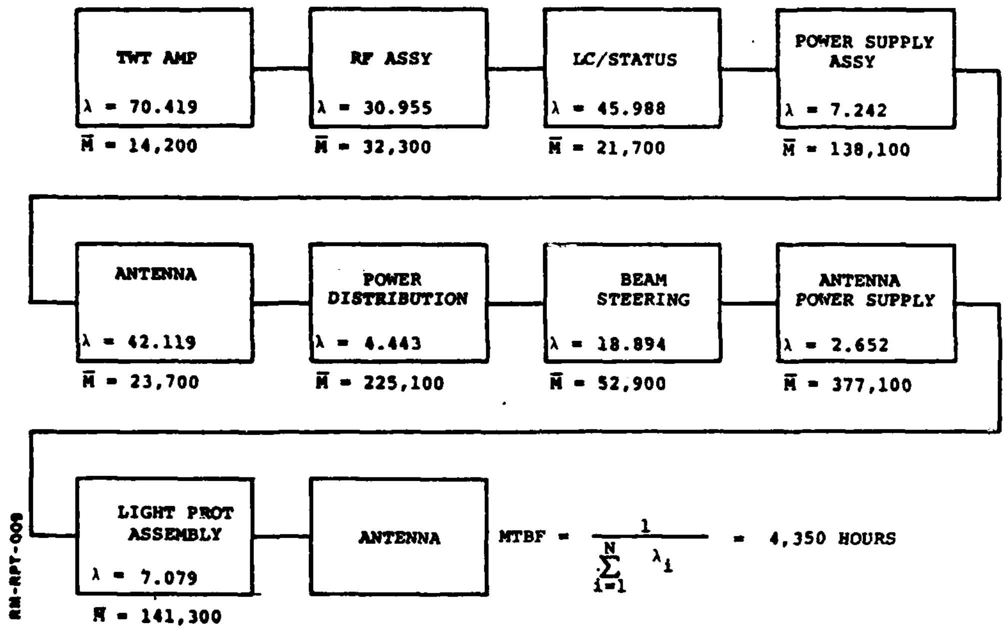


FIGURE C.9. SMALL COMMUNITY AZ ACTIVE RELIABILITY MODEL

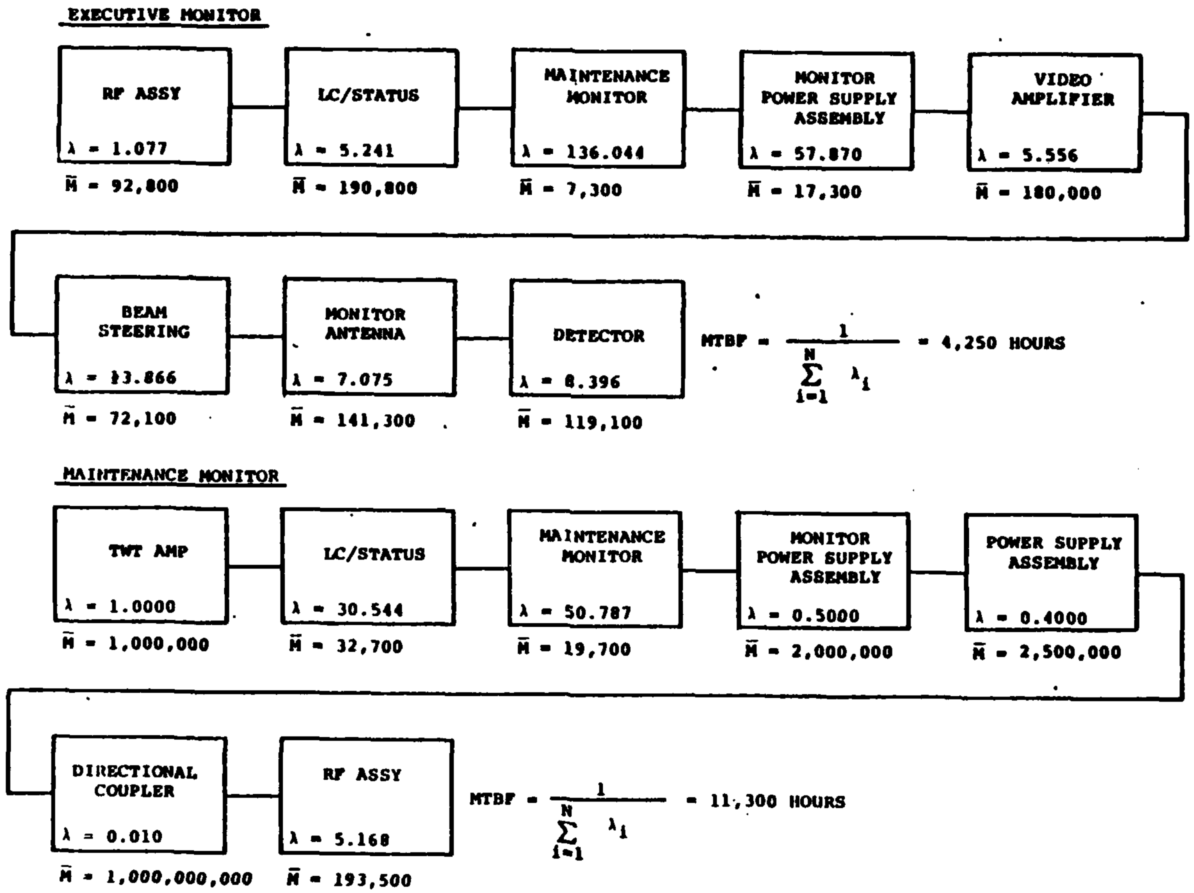


FIGURE C.10. SMALL COMMUNITY AZ MONITOR RELIABILITY MODEL

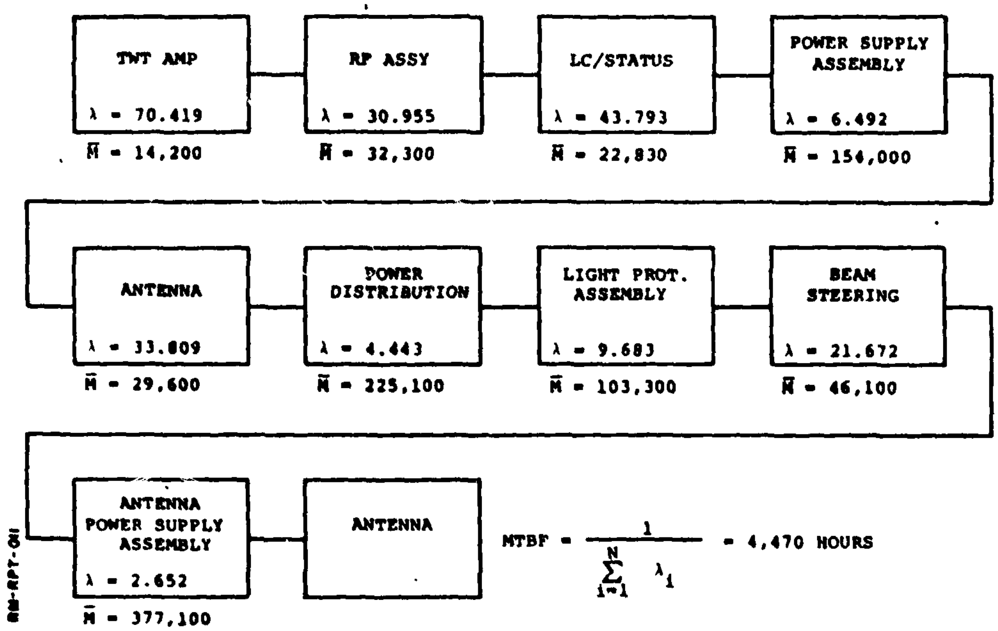


FIGURE C.11. SMALL COMMUNITY EL ACTIVE RELIABILITY MODEL

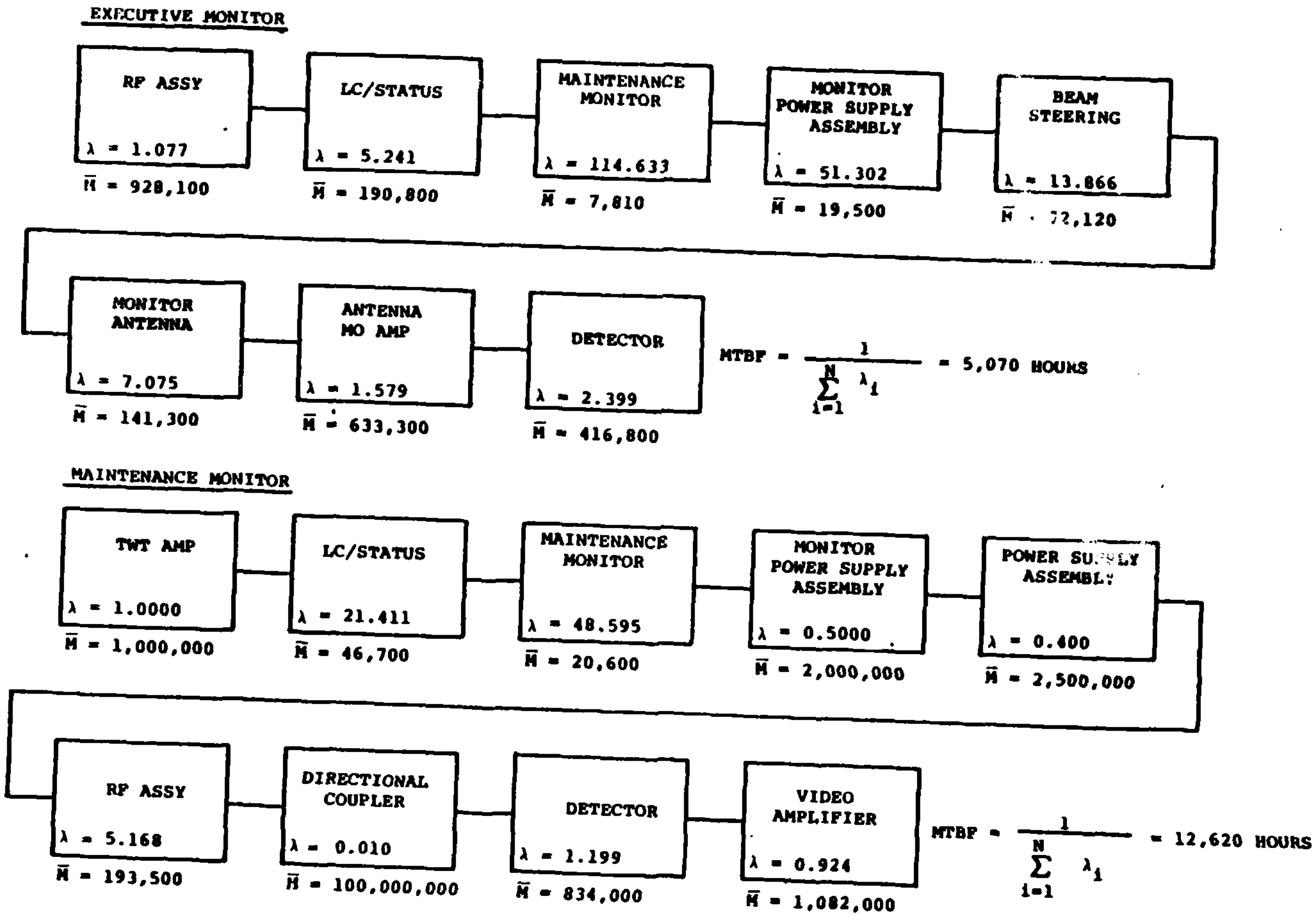


FIGURE C.12. SMALL COMMUNITY EL MONITOR RELIABILITY MODEL

ASSEMBLY	SUBASSEMBLY	BOARD		(F.R.1)
ACTIVE EQUIP	TWT AMP A1A1	CHASSIS	(Q= 1)	10.02481
ACTIVE EQUIP	TWT AMP A1A1	PCB	(Q= 1)	8.73740
ACTIVE EQUIP	TWT AMP A1A1	H/V BOX	(Q= 1)	1.63187
ACTIVE EQUIP	TWT AMP A1A1	RF COMPONE	(Q= 1)	50.02470
ACTIVE EQUIP	RF ASSY A1A2		(Q= 1)	1.84141
ACTIVE EQUIP	RF ASSY A1A2	EXCITER A1A2A1	(Q= 1)	13.17267
ACTIVE EQUIP	RF ASSY A1A2	DPSK ASSY A1A2A2	(Q= 1)	3.59803
ACTIVE EQUIP	RF ASSY A1A2	AMP MOD A1A2A3	(Q= 1)	10.72309
ACTIVE EQUIP	RF ASSY A1A2	ISOLATOR A1A2AT1	(Q= 1)	0.76745
ACTIVE EQUIP	RF ASSY A1A2	ATTEN, RF A1A2AT2	(Q= 1)	0.85252
ACTIVE EQUIP	LC/STATUS A1A3		(Q= 1)	8.70997
ACTIVE EQUIP	LC/STATUS A1A3	SYST SYNC A1A3A3	(Q= 1)	2.25647
ACTIVE EQUIP	LC/STATUS A1A3	DATA LINK A1A3A4	(Q= 1)	5.80521
ACTIVE EQUIP	LC/STATUS A1A3	MORSE COD A1A3A15	(Q= 1)	4.09130
ACTIVE EQUIP	LC/STATUS A1A3	ID/BD/DPS A1A3A16	(Q= 1)	4.54739
ACTIVE EQUIP	LC/STATUS A1A3	SYS TIM GEA1A3A17	(Q= 1)	6.71834
ACTIVE EQUIP	LC/STATUS A1A3	TIM CNTRL A1A3A18	(Q= 1)	10.18422
ACTIVE EQUIP	LC/STATUS A1A3	10 MHZ DR A1A3A19	(Q= 1)	0.28188
ACTIVE EQUIP	LC/STATUS A1A3	10 MHZ OSCA1A3Y1	(Q= 1)	3.39331
ACTIVE EQUIP	PS ASSY A1A6		(Q= 1)	2.35052
ACTIVE EQUIP	PS ASSY A1A6	20V P.SUPPA1A6PS5	(Q= 1)	1.19403
ACTIVE EQUIP	PS ASSY A1A6	15V P.SUPPA1A6PS2	(Q= 1)	2.49364
ACTIVE EQUIP	PS ASSY A1A6	5V P.SUPP A1A6PS1	(Q= 1)	1.20357
ACTIVE EQUIP	ANTENNA	SCAN SWIT A1S1-4	(Q= 4)	9.52579
ACTIVE EQUIP	ANTENNA	SCAN MOD. A1A8	(Q= 1)	30.15826
ACTIVE EQUIP	ANTENNA	ANT.SEL.SWA1S5-6	(Q= 2)	2.43469
ACTIVE EQUIP	PWR.DIST A1N1		(Q= 1)	4.44293
ACTIVE EQUIP	BM STEER. A1A7		(Q= 1)	5.34173
ACTIVE EQUIP	BM STEER. A1A7	SCAN CNTR A1A7A1	(Q= 1)	7.29437
ACTIVE EQUIP	BM STEER. A1A7	SC.CN.COMPA1A7A2	(Q= 1)	3.61681
ACTIVE EQUIP	BM STEER. A1A7	10 MHZ OSCA1A7Y1	(Q= 1)	2.64071
ACTIVE EQUIP	ANT.PS.ASYA1A6		(Q= 1)	0.08207
ACTIVE EQUIP	ANT.PS.ASYA1A6	24V P.SUPPA1A6PS4	(Q= 1)	1.10738
ACTIVE EQUIP	ANT.PS.ASYA1A6	40V P.SUPPA1A6PS3	(Q= 1)	1.46212
ACTIVE EQUIP	L.P.ASSY A1A10	LPB NO1 A1A10A1	(Q= 1)	1.79791
ACTIVE EQUIP	L.P.ASSY A1A10	LPB NO5 A1A10A2	(Q= 1)	5.28136
ACTIVE EQUIP			(Q= 1)	0.00000

OVERALL FAILURE RATES FOR THIS EQUIPMENT 229.78973

OVERALL MTBF FOR THIS EQUIPMENT 4351.80567

FIGURE C.13. SMALL COMMUNITY AZ ACTIVE RELIABILITY PREDICTIONS

ASSEMBLY	SUBASSEMBLY	BOARD		(F.R.1)
EXEC MON EQUIP	RF ASSY A1A1	DET AMP A1A2AR	(Q= 1)	1.07747
EXEC MON EQUIP	LC/STATUS A1A3	SEQ/TIMER A1A3A2	(Q= 1)	5.24076
EXEC MON EQUIP	MAINT.MON A1A4	EXEC INT. P/O A1A4	(Q= 5)	35.84455
EXEC MON EQUIP	MAINT.MON A1A4	MON CNTRL A1A4A6	(Q= 1)	2.60450
EXEC MON EQUIP	MAINT.MON A1A4	MORSE COD A1A4A7	(Q= 1)	4.55980
EXEC MON EQUIP	MAINT.MON A1A4	DPSK DECO A1A4A8	(Q= 1)	3.06096
EXEC MON EQUIP	MAINT.MON A1A4	DPSK DECI A1A4A9	(Q= 1)	5.88183
EXEC MON EQUIP	MAINT.MON A1A4	DISC DATA A1A4A10	(Q= 1)	2.11019
EXEC MON EQUIP	MAINT.MON A1A4	RECL. DR. A1A4A23	(Q= 1)	1.79492
EXEC MON EQUIP	MAINT.MON A1A4	ID/BD/DPS A1A4A25	(Q= 1)	4.54739
EXEC MON EQUIP	MAINT.MON A1A4	SYS TIM GEA1A4A26	(Q= 1)	7.40043
EXEC MON EQUIP	MAINT.MON A1A4	MON TIM A1A4A28	(Q= 1)	5.57079
EXEC MON EQUIP	MAINT.MON A1A4	SCAN TIM A1A4A29	(Q= 1)	19.70799
EXEC MON EQUIP	MAINT.MON A1A4	AN.COM.#1 A1A4A30	(Q= 1)	7.33790
EXEC MON EQUIP	MAINT.MON A1A4	DET/COMP A1A4A31	(Q= 1)	2.94232
EXEC MON EQUIP	MAINT.MON A1A4	BE ACC CO A1A4A32	(Q= 1)	9.24046
EXEC MON EQUIP	MAINT.MON A1A4	DIG COMP. A1A4A33	(Q= 1)	12.90176
EXEC MON EQUIP	MAINT.MON A1A4	FREQ MON. A1A4A34	(Q= 1)	7.87391
EXEC MON EQUIP	MAINT.MON A1A4	TIMING REFA1A4A27	(Q= 1)	2.46390
EXEC MON EQUIP	MON PS ASYA1A5		(Q= 1)	6.28778
EXEC MON EQUIP	MON PS ASYA1A5	C BAND LO A1A5A1A1	(Q= 1)	13.17267
EXEC MON EQUIP	MON PS ASYA1A5	RF MODULE A1A5A1A2	(Q= 1)	27.43653
EXEC MON EQUIP	MON PS ASYA1A5	REG/BUFFERA1A5A1A3	(Q= 1)	1.05550
EXEC MON EQUIP	MON PS ASYA1A5	MIXER A1A5A1Z1	(Q= 1)	0.90727
EXEC MON EQUIP	MON PS ASYA1A5	PWR DIV.	(Q= 1)	1.17393
EXEC MON EQUIP	MON PS ASYA1A5	50 OHM TER	(Q= 1)	2.94888
EXEC MON EQUIP	MON PS ASYA1A5	5V P.SUPP A1A5PS1/2	(Q= 2)	2.39564
EXEC MON EQUIP	MON PS ASYA1A5	15V P.SUP A1A5PS3	(Q= 1)	2.49160
EXEC MON EQUIP	VIDEO AMP A1AR		(Q= 7)	5.55569
EXEC MON EQUIP	DETECTOR A1CR		(Q= 7)	8.39589
EXEC MON EQUIP	BM STEER A1A7	SC.CN.MON.A1A7A3	(Q= 1)	7.63475
EXEC MON EQUIP	BM STEER A1A7	SS MONITORA1A7A4	(Q= 1)	6.23126
EXEC MON EQUIP	MON ANT A2	BOX ASSY A2N1	(Q= 1)	2.48955
EXEC MON EQUIP	MON ANT A2	LIGHT PROTA2N2A1	(Q= 1)	0.91843
EXEC MON EQUIP	MON ANT A2	VIDEO AMP A2N2AR1A1	(Q= 1)	0.99372
EXEC MON EQUIP	MON ANT A2	RF DET A2N2CR1	(Q= 1)	1.10134
EXEC MON EQUIP	MON ANT A2	BAND FILT A2N2FL1	(Q= 1)	0.62870
EXEC MON EQUIP	MON ANT A2	PWR DIV A2N2Z1	(Q= 1)	0.94305
MAINT MON EQUIP	TWT AMP A1A1	CHASSIS	(Q= 1)	1.00000
MAINT MON EQUIP	RF ASSY A1A2	TERMIN. A1A2A3-5	(Q= 3)	2.55757
MAINT MON EQUIP	RF ASSY A1A2	DETECTOR A1A2CR1/2	(Q= 2)	2.61000
MAINT MON EQUIP	LC/STATUS A1A3		(Q= 1)	24.21739
MAINT MON EQUIP	LC/STATUS A1A3	LT DR/ALM A1A3A1	(Q= 1)	4.32637
MAINT MON EQUIP	LC/STATUS A1A3	LC/ST.IND.A1A3A20	(Q= 1)	1.99999
MAINT MON EQUIP	MAINT.MON A1A4		(Q= 1)	7.85681
MAINT MON EQUIP	MAINT.MON A1A4	MAINT INT.P/O A1A4	(Q= 3)	19.33687
MAINT MON EQUIP	MAINT.MON A1A4	MAIN.MO.INA1A4A35	(Q= 1)	8.39999
MAINT MON EQUIP	MAINT.MON A1A4	AN.COM.#3 A1A4A11	(Q= 1)	7.59948
MAINT MON EQUIP	MAINT.MON A1A4	AN.COM.#2 A1A4A13	(Q= 1)	7.59394
MAINT MON EQUIP	MON PS ASYA1A5		(Q= 1)	0.50000
MAINT MON EQUIP	PS ASSY A1A6		(Q= 1)	0.40000
MAINT MON EQUIP	DIR CPLR A1DC1		(Q= 1)	0.01000
OVERALL FAILURE RATES FOR THIS EQUIPMENT				323.53180
OVERALL MTBF FOR THIS EQUIPMENT				3090.88721

FIGURE C.14. SMALL COMMUNITY AZ MONITOR RELIABILITY PREDICTIONS

ASSEMBLY	SUBASSEMBLY		BOARD		(F.R.1)
ACTIVE EQUIP	TWT AMP	A1A1	CHASSIS	(Q= 1)	10.02481
ACTIVE EQUIP	TWT AMP	A1A1	PCB	(Q= 1)	8.73740
ACTIVE EQUIP	TWT AMP	A1A1	H/V BOX	(Q= 1)	1.63187
ACTIVE EQUIP	TWT AMP	A1A1	RF COMPONE	(Q= 1)	50.02470
ACTIVE EQUIP	RF ASSY	A1A2		(Q= 1)	1.84141
ACTIVE EQUIP	RF ASSY	A1A2	EXCITER A1A2A1	(Q= 1)	13.17267
ACTIVE EQUIP	RF ASSY	A1A2	DPSK ASSY A1A2A2	(Q= 1)	3.59803
ACTIVE EQUIP	RF ASSY	A1A2	AMP MOD A1A2A3	(Q= 1)	10.72309
ACTIVE EQUIP	RF ASSY	A1A2	ISOLATOR A1A2AT1	(Q= 1)	0.76745
ACTIVE EQUIP	RF ASSY	A1A2	ATTEN, RF A1A2AT2	(Q= 1)	0.85252
ACTIVE EQUIP	LC/STATUS	A1A3		(Q= 1)	6.61000
ACTIVE EQUIP	LC/STATUS	A1A3	SYST SYNC A1A3A3	(Q= 1)	5.13866
ACTIVE EQUIP	LC/STATUS	A1A3	DATA LINK A1A3A4	(Q= 1)	5.80521
ACTIVE EQUIP	LC/STATUS	A1A3	ID/BD/DPS A1A3A16	(Q= 1)	4.54739
ACTIVE EQUIP	LC/STATUS	A1A3	SYS TIM GEA1A3A17	(Q= 1)	6.61203
ACTIVE EQUIP	LC/STATUS	A1A3	TIM CNTRL A1A3A18	(Q= 1)	11.40408
ACTIVE EQUIP	LC/STATUS	A1A3	10 MHZ DR A1A3A19	(Q= 1)	0.28188
ACTIVE EQUIP	LC/STATUS	A1A3	10 MHZ OSCA1A3Y1	(Q= 1)	3.39331
ACTIVE EQUIP	PS ASSY	A1A6		(Q= 1)	1.60052
ACTIVE EQUIP	PS ASSY	A1A6	20V P.SUPPA1A6PS5	(Q= 1)	1.19403
ACTIVE EQUIP	PS ASSY	A1A6	15V P.SUPPA1A6PS2	(Q= 1)	2.49364
ACTIVE EQUIP	PS ASSY	A1A6	5V P.SUPP A1A6PS1	(Q= 1)	1.20357
ACTIVE EQUIP	ANTENNA		SCAN SWIT A1S1-S4	(Q= 1)	2.38144
ACTIVE EQUIP	ANTENNA		SCAN MOD. A1A8	(Q= 1)	30.15826
ACTIVE EQUIP	ANTENNA		ANT SEL SWA1S5	(Q= 1)	1.26945
ACTIVE EQUIP	PWR.DIST	A1N1		(Q= 1)	4.44293
ACTIVE EQUIP	BM STEER.	A1A7		(Q= 1)	8.11975
ACTIVE EQUIP	BM STEER.	A1A7	SCAN CNTR A1A7A1	(Q= 1)	7.29437
ACTIVE EQUIP	BM STEER.	A1A7	SC.CN.COMPA1A7A2	(Q= 1)	3.61681
ACTIVE EQUIP	BM STEER.	A1A7	10 MHZ OSCA1A7Y1	(Q= 1)	2.64071
ACTIVE EQUIP	ANT.PS.ASYA1A6			(Q= 1)	0.08207
ACTIVE EQUIP	ANT.PS.ASYA1A6		24V P.SUPPA1A6PS4	(Q= 1)	1.10738
ACTIVE EQUIP	ANT.PS.ASYA1A6		40V P.SUPPA1A6PS3	(Q= 1)	1.46212
ACTIVE EQUIP	L.P.ASSY	A1A10	LPB NO1 A1A10A1	(Q= 1)	3.09486
ACTIVE EQUIP	L.P.ASSY	A1A10	LPB NO2 A1A10A2	(Q= 1)	1.31941
ACTIVE EQUIP	L.P.ASSY	A1A10	LPB NO5 A1A10A3	(Q= 1)	5.26907

OVERALL FAILURE RATES FOR THIS EQUIPMENT 223.91665

OVERALL MTBF FOR THIS EQUIPMENT 4465.94825

FIGURE C.15. SMALL COMMUNITY AZ ACTIVE RELIABILITY PREDICTIONS

ASSEMBLY	SUBASSEMBLY	BOARD		(F.R.1)
EXEC MON EQUIP	RF ASSY A1A2	DET AMP A1A2AR1	(Q= 1)	1.07747
EXEC MON EQUIP	LC/STATUS A1A3	SEQ/TIMER A1A3A2	(Q= 1)	5.24076
EXEC MON EQUIP	MAINT.MON A1A4	EXEC INT. P/O A1A4	(Q= 3)	21.50672
EXEC MON EQUIP	MAINT.MON A1A4	MON CNTRL A1A4A6	(Q= 1)	2.60450
EXEC MON EQUIP	MAINT.MON A1A4	DPSK DECO A1A4A8	(Q= 1)	3.06096
EXEC MON EQUIP	MAINT.MON A1A4	DPSK DECI A1A4A9	(Q= 1)	5.88183
EXEC MON EQUIP	MAINT.MON A1A4	DISC DATA A1A4A10	(Q= 1)	2.11019
EXEC MON EQUIP	MAINT.MON A1A4	RECL DR A1A4A23	(Q= 1)	1.79492
EXEC MON EQUIP	MAINT.MON A1A4	ID/BD/DPS A1A4A25	(Q= 1)	4.54739
EXEC MON EQUIP	MAINT.MON A1A4	SYS TIM GEA1A4A26	(Q= 1)	7.40043
EXEC MON EQUIP	MAINT.MON A1A4	MON TIM A1A4A28	(Q= 1)	5.57079
EXEC MON EQUIP	MAINT.MON A1A4	SCAN TIM A1A4A29	(Q= 1)	19.70799
EXEC MON EQUIP	MAINT.MON A1A4	AN.COM.#1 A1A4A30	(Q= 1)	7.33790
EXEC MON EQUIP	MAINT.MON A1A4	DET/COMP A1A4A31	(Q= 1)	2.94232
EXEC MON EQUIP	MAINT.MON A1A4	BE ACC CO A1A4A32	(Q= 1)	6.88211
EXEC MON EQUIP	MAINT.MON A1A4	DIG COMP. A1A4A33	(Q= 1)	12.90176
EXEC MON EQUIP	MAINT.MON A1A4	FREQ MON. A1A4A34	(Q= 1)	7.87391
EXEC MON EQUIP	MAINT.MON A1A4	TIMING REFA1A4A27	(Q= 1)	2.50953
EXEC MON EQUIP	MON PS ASYA1A5		(Q= 1)	3.84278
EXEC MON EQUIP	MON PS ASYA1A5	C BAND LO A1A5A1A1	(Q= 1)	13.17267
EXEC MON EQUIP	MON PS ASYA1A5	RF MODULE A1A5A1A2	(Q= 1)	27.43653
EXEC MON EQUIP	MON PS ASYA1A5	REG/BUFFERA1A5A1A3	(Q= 1)	1.05550
EXEC MON EQUIP	MON PS ASYA1A5	MIXER A1A5A1Z1	(Q= 1)	0.90727
EXEC MON EQUIP	MON PS ASYA1A5	5V P.SUPP A1A5PS1	(Q= 2)	2.39564
EXEC MON EQUIP	MON PS ASYA1A5	15V P.SUP A1A5PS3	(Q= 1)	2.49160
EXEC MON EQUIP	BM STEER A1A7	SC.CN.MON.A1A7A3	(Q= 1)	7.63475
EXEC MON EQUIP	BM STEER A1A7	SS MONITORA1A7A4	(Q= 1)	6.23126
EXEC MON EQUIP	ANT MO AMPA1E1AR1/2		(Q= 2)	1.57877
EXEC MON EQUIP	RF DETEC A1E1CR1/2		(Q= 2)	2.39882
EXEC MON EQUIP	MON ANT A2	BOX ASSY A2N1	(Q= 1)	2.48955
EXEC MON EQUIP	MON ANT A2	LPB NO 3 A2N2A1	(Q= 1)	0.91843
EXEC MON EQUIP	MON ANT A2	VIDEO AMP A2N2AR1	(Q= 1)	0.99372
EXEC MON EQUIP	MON ANT A2	RF DET A2N2CR1	(Q= 1)	1.10134
EXEC MON EQUIP	MON ANT A2	BAND FILT A2N2FL1	(Q= 1)	0.62870
EXEC MON EQUIP	MON ANT A2	PWR DIV A2N2Z1	(Q= 1)	0.94305
MAINT MON EQUIP	TWT AMP A1A1	CHASSIS	(Q= 1)	1.00000
MAINT MON EQUIP	RF ASSY A1A2	TERM A1A2AT3-5	(Q= 3)	2.55757
MAINT MON EQUIP	RF ASSY A1A2	DETECTOR A1A2CR1-2	(Q= 2)	2.61000
MAINT MON EQUIP	LC/STATUS A1A3		(Q= 1)	15.08483
MAINT MON EQUIP	LC/STATUS A1A3	LT DR/ALM A1A3A1	(Q= 1)	4.32637
MAINT MON EQUIP	LC/STATUS A1A3	LC/ST.IND.A1A3A20	(Q= 1)	1.99999
MAINT MON EQUIP	MAINT.MON A1A4		(Q= 1)	6.26489
MAINT MON EQUIP	MAINT.MON A1A4	MAINT INT.P/O A1A4	(Q= 3)	19.33687
MAINT MON EQUIP	MAINT.MON A1A4	MAIN.MO.INA1A4A35	(Q= 1)	7.80000
MAINT MON EQUIP	MAINT.MON A1A4	AN.COM.#3 A1A4A11	(Q= 1)	7.59941
MAINT MON EQUIP	MAINT.MON A1A4	AN.COM.#2 A1A4A13	(Q= 1)	7.59394
MAINT MON EQUIP	MON PS ASYA1A5		(Q= 1)	0.50000
MAINT MON EQUIP	PS ASSY A1A6		(Q= 1)	0.40000
MAINT MON EQUIP	DIR CPLR A1DC1		(Q= 1)	0.01000
MAINT MON EQUIP	RF DETECTOA1CR3		(Q= 1)	1.19941
MAINT MON EQUIP	VIDEO AMP A1A1AR1		(Q= 1)	0.92415
OVERALL FAILURE RATES FOR THIS EQUIPMENT				276.37878
OVERALL MTBF FOR THIS EQUIPMENT				3618.22363

FIGURE C.16. SMALL COMMUNITY AZ MONITOR RELIABILITY PREDICTIONS

supplying hardware. In view of these factors, and based on Bendix experience on other contracts for "best commercial practice" equipment, it is fully expected that the MTBF's that will be achieved in the field will lie closer to the MTBF of a full FAA-2100 design than it will to the bottom limit predicted.

C.3.2 MAINTAINABILITY

The results of the maintainability predictions yield an MTTR of 0.42 hours for the Basic Narrow Configuration and 0.41 hours for the Small Community Configuration.

MIL-HDBK-472, procedure III was used to make the predictions.

Figure C.17 gives a functional level diagram for the ground subsystem and indicates the levels of localization to the LRU by means of built-in front panel and internal indicators. From this functional level diagram, seven general categories of maintenance action were identified. The checklist scoring technique of procedure III was applied to these seven types of actions and a corrective maintenance time determined for each. These individual maintenance times were then weighted by the probability of occurrence (ratio of individual item failure rate to the total system failure rate) to arrive at the overall MTTR

The checklist scores and details of the maintainability calculations by individual item are given in Supplement A.

C.3.3 FAILURE MODES AND EFFECTS ANALYSIS

A Failure Modes and Effects Analysis was performed to determine the effectiveness of the monitor equipment to detect all failures and to identify the effect of hardware failures on system performance.

C.3.3.1 Analysis Method

A series of matrices were developed which define the effect of hardware failures on the functional operation of the

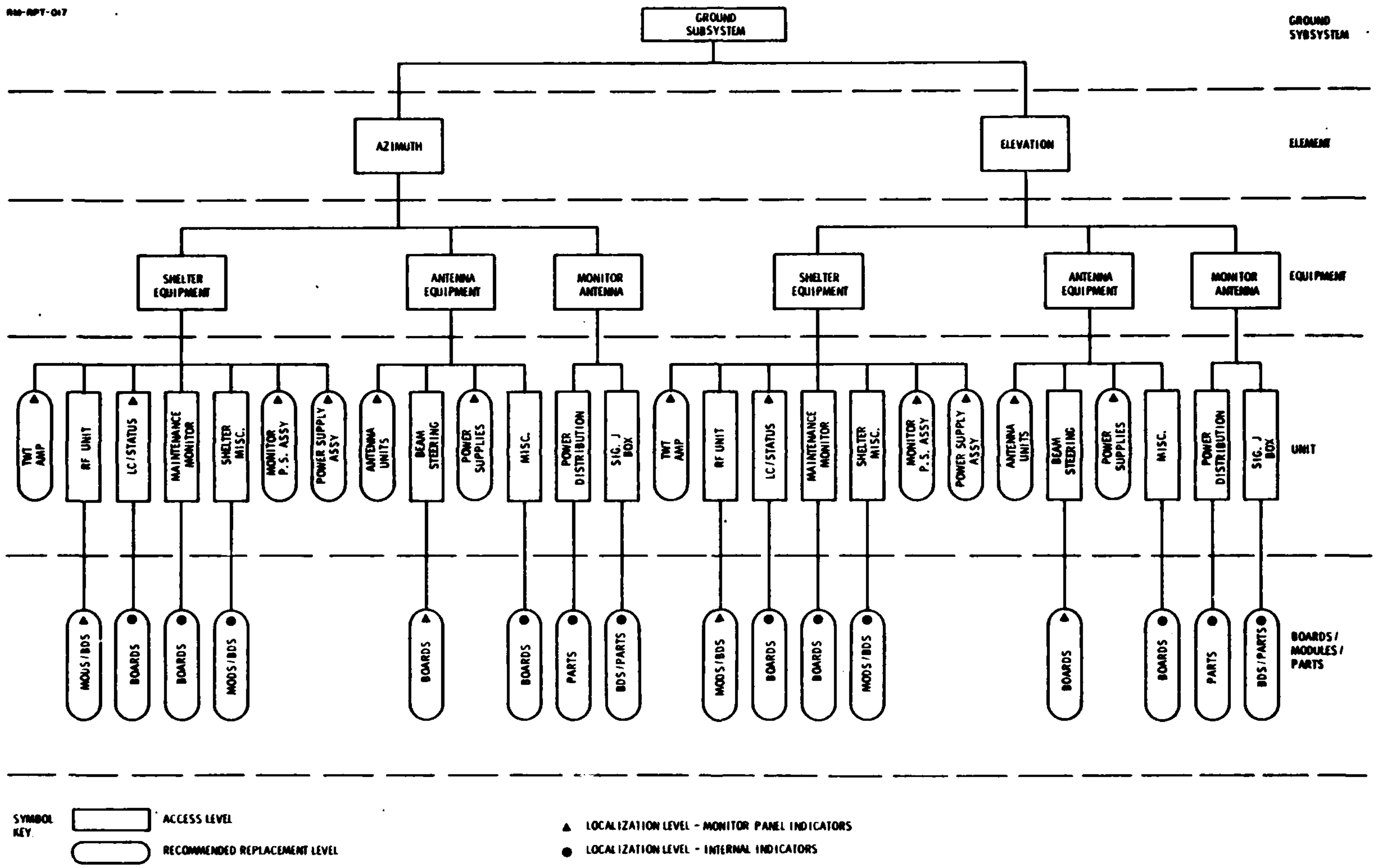


FIGURE C.17. MAINTAINABILITY FUNCTIONAL LEVEL DIAGRAM

system, and also define the monitor function which detects the failure and downgrades the system.

The analysis was performed starting at the board functional interface level, establishing the functional relationships between circuit boards. These relationships were then traced until the ultimate effect on the system output was established. The system output effects were categorized into four aspects of the radiated signal:

a. Carrier Frequency
b. Carrier Phase Timing
c. Power ON/OFF and Antenna Selection Timing
d. Carrier Amplitude versus Steering Position

The above analysis was then used as the criteria for determining criticality of hardware items in evaluating the executive monitor's ability to detect all failures, and perform the executive downgrading function.

C.3.3.2 Analysis Results

Figure C.18 is the composite matrix which shows the cause/effect relationships of the various hardware failures (cause) on the four critical aspects of the radiated signal (effect). The numbers in the body of the table indicate the estimated ratios of the particular hardware items which will cause the indicated effect on the system output signal.

An additional matrix is shown in Figure C.19. This matrix illustrates the maintenance monitor panel indications (effect) upon the occurrence of particular hardware failures (cause), and is intended as a maintenance aid in troubleshooting the hardware. The numbers in the body of the table are approximate ratio of the hardware failures for a particular equipment which will result in the indicated symptom.

	CARRIER FREQ.	CARRIER PHASE VS. TIME	CARRIER ON/OFF VS. TIME	CARRIER AMPL. VS. POSITION
STG FAIL. (TIMING)	0	0.6	0.6	0.8
10 MHz FAIL. (TIMING)	0	1.0	1.0	1.0
MORSE CODE GEN. (TIMING)	0	1.0	1.0	1.0
DATA LINK FAILURE (L.C.)	0	1.0	1.0	1.0
592 MSEC DRIV. FAIL (L.C.)	0	1.0	1.0	1.0
SEQ/TIMER FAIL (L.C.)	0	1.0	1.0	1.0
LIGHT DRIVER (L.C.)	0	0	0	0
10 MHz OSC. FAIL (B.S.)	0	0	0	1.0
SCAN CONTROL LOGIC (B.S.)	0	0	0	1.0
SCAN CONTROL MON. COMP. (B.S.)	0	0	0	0
SCAN CONTROL MON. (B.S.)	0	0	0	0
SCAN SWITCH DRIVER (B.S.)	0	0	0	0.3
INT. SCAN SWITCH DRIVER (B.S.)	0	0	0	0.3
SCAN SWITCH MON. (B.S.)	0	0	0	0
ID/BASIC DATA/DPSK GEN. (TIMING)	0	0.8	0.6	0
TIMING CONTROL (TIMING)	0	0.9	0.9	0
AUX. DATA - 5 CARDS (TIMING)	0	0.9	0.1	0
EXCITER FAILURE (XMTR-EXC.)	1.0	0	1.0	0
Φ MODULATOR (XMTR-EXC.)	0	1.0	1.0	0
DPSK DRIVER (XMTR-EXC.)	0	1.0	0	0
ISOL (XMTR-EXC.)	0	0	1.0	0
AMP MOD (XMTR-EXC.)	0	0	1.0	0
VAR. ATTEN (XMTR-EXC.)	0	0	1.0	0
TWTA	0	0	1.0	0
MONITOR RCVR AND PEAK DETECTOR (TM MONITOR)	0	0	0	0
ID/BASIC DATA/DPSK GENERATOR (TM MONITOR)	0	0	0	0
SYSTEM TIMING GENERATOR (TM MONITOR)	0	0	0	0
MORSE CODE GENERATOR (TM MONITOR)	0	0	0	0
AUX/ID/ADD/PARITY GENERATOR (TM MONITOR)	0	0	0	0
MONITOR DECODE (TM MONITOR)	0	0	0	0
MONITOR DECISION (TM MONITOR)	0	0	0	0
MONITOR CONTROL (ROLLO)	0	0	0	0
MONITOR TIMING BD (ROLLO)	0	0	0	0
SCAN TIMING BD (ROLLO)	0	0	0	0
EXEC. INT. BD (ROLLO)	0	0	0	0
MAINT. INT. BD (ROLLO)	0	0	0	0
ANAL. COMP. BD (ROLLO)	0	0	0	0
DIGITAL COMP. BD (ROLLO)	0	0	0	0
DISC. DATA BD (ROLLO)	0	0	0	0
FAR FIELD ANTENNA (RF MON.)	0	0	0	0
OMNI DET (RF MON.)	0	0	0	0
RSLS DET (RF MON.)	0	0	0	0
LSLS DET (RF MON.)	0	0	0	0
TEST PULSE LOGIC (RF MON.)	0	0	0	0
ANGLE LOGIC (RF MON.)	0	0	0	0
SCAN SWITCH (ANT.)	0	0	0	1.0
SCAN MOD. (ANT.)	0	0	0	1.0
LENS FAILURE	0	0	1.0	1.0
OMNI ANT. FAIL (ANT.)	0	1.0	1.0	0
RSLS ANT. FAIL (ANT.)	0	0	0	1.0
LSLS ANT. FAIL (ANT.)	0	0	0	1.0
AUX. DATA INPUT	0	1.0	0	0

FIGURE C.18. BASIC NARROW FAILURE MATRIX

	BEAM ACCURACY	TEST PULSE ACCURACY	BEAM ERP	FORWARD OMNI ERP	SLS ERP, LEFT	SLS ERP, RIGHT	PREAMBLE	SITE FREQUENCY	ANT SW MON	SCAN MOD MON	SCAN CONTROL	DME REPLY DELAY	MONITOR TIMING	LOCAL CONTROL PANEL	BASIC DATA WORD 1	AUX DATA	XMTR POWER OUT	EXC POWER OUT	DATA INPUT	PHASE MODULATOR	AMPLITUDE MODULATOR	ELEC TEMP	ANTENNA TEMP	INTERCOMM MON	SYSTEM STATUS, EXEC	SYSTEM STATUS, MAINT
STG (TIMING)	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0	0.9	0.9	0.9	0	0	0.8	0.8	0.8	0.8	0	0	0.8	0.8	0	0	0.8	0.8	0.8
10 MHz (TIMING)	0	1.0	1.0	1.0	1.0	1.0	1.0	0	1.0	1.0	1.0	0	1.0	1.0	1.0	1.0	1.0	0	0	1.0	1.0	0	0	1.0	1.0	1.0
MORSE CODE GEN (TIMING)	0	0	0	0	0	0	1.0	0	0	0	0	0	0	0	0	0	0	0	0	1.0	1.0	0	0	0	0	1.0
DATA LINK (L.C.)	0	0	0	0	0	0	0	0	0	0	0	0	0	1.0	0	0	0	0	0	0	0	0	0	0.5	1.0	0.5
592 MS DRIV. (L.C.)	0	0	0	0	0	0	0	0	0	0	0	0	0	1.0	0	0	0	0	0	0	0	0	0	1.0	1.0	1.0
SEQ/TIMER (L.C.)	0	0	0	0	0	0	0	0	0	0	0	0	0	0.2	0	0	0	0	0	0.1	0.1	0	0	0.3	0.2	0.3
LIGHT DRIV. (L.C.)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10 MHz OSC (B.S.)	1.0	0	1.0	0	0	0	0	0	1.0	1.0	1.0	0	0	0	0	0	0	0	0	0	0	0	0	0	1.0	0
SCAN CNTRL LOGIC (B.S.)	1.0	0	1.0	0	0	0	0	0	1.0	1.0	1.0	0	0	0	0	0	0	0	0	0	0	0	0	0	1.0	0
SCAN CNTRL MON COMP (B.S.)	0	0	0	0	0	0	0	0	1.0	1.0	1.0	0	0	0	0	0	0	0	0	0	0	0	0	0	1.0	0
SCAN CNTRL MON (B.S.)	0	0	0	0	0	0	0	0	1.0	1.0	1.0	0	0	0	0	0	0	0	0	0	0	0	0	0	1.0	0
SCAN SW DRIV (B.S.)	1.0	0	1.0	0	0	0	0	0	1.0	0	1.0	0	0	0	0	0	0	0	0	0	0	0	0	0	1.0	0
INT SCAN SW. DRIV (B.S.)	1.0	0	1.0	0	0	0	0	0	1.0	0	1.0	0	0	0	0	0	0	0	0	0	0	0	0	0	1.0	0
SCAN SW MON (B.S.) (3 CARDS)	0	0	0	0	0	0	0	0	1.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1.0	0
ID/BASIC DATA/DPSK GEN (TIMING)	0	0	0	0	0	0	0.8	0	0	0	0	0	0	0	0.5	0.2	0	0	0	0.8	0.8	0	0	0	0.8	0.8
TIMING CNTRL (TIMING)	0.8	0.8	0.8	0.8	0.8	0.8	0.5	0	1.0	1.0	1.0	0	0	0	0.3	0.3	0.5	0	0	0	0.8	0	0	0	0.8	0.8
AUX DATA (TIMING)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1.0	0	0	0	0	0	0	0	0	0	1.0
EXCITER (EXC-MOD)	0	0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	0	0	0	0	1.0	1.0	1.0	1.0	0	0	0	0	0	0	1.0	1.0
Ø MODULATOR (EXC-MOD)	0	0	1.0	1.0	0	0	1.0	0	0	0	0	0	0	0	1.0	1.0	1.0	0	0	0	0	0	0	0	1.0	1.0
DPSK DRIVER (EXC-MOD)	0	0	1.0	1.0	0	0	1.0	0	0	0	0	0	0	0	1.0	1.0	1.0	0	0	1.0	0	0	0	0	1.0	1.0
ISOLATOR (EXC-MOD)	0	0	1.0	1.0	1.0	1.0	1.0	0	1.0	1.0	0	0	0	0	1.0	1.0	1.0	0	0	0	0	0	0	0	1.0	1.0
AMP MOD (EXC-MOD)	0	1.0	1.0	1.0	1.0	1.0	1.0	0	1.0	1.0	0	0	0	0	1.0	1.0	1.0	0	0	0	1.0	0	0	0	1.0	1.0
VAR ATTEN (EXC-MOD)	0	0	1.0	1.0	1.0	1.0	1.0	0	1.0	1.0	0	0	0	0	1.0	1.0	1.0	0	0	0	0	0	0	0	1.0	1.0
TWTA (XMTR)	0	0	1.0	1.0	1.0	1.0	1.0	0	1.0	1.0	0	0	0	0	1.0	1.0	1.0	0	0	0	0	0	0	0	1.0	1.0
XFER SW. (XMTR)	0	0	1.0	1.0	1.0	1.0	1.0	0	1.0	1.0	0	0	0	0	1.0	1.0	0	0	0	0	0	0	0	0	1.0	1.0
MONITOR RCVR & PEAK DET (TIM. MON)	1.0	1.0	0	0	0	0	1.0	0	0	0	0	0	0	0	1.0	1.0	0	0	0	0	0	0	0	0	1.0	1.0
DPSK CNTRL (TIM. MON.)	0	0	0	0	0	0	1.0	0	0	0	0	0	0	0	0.5	0.2	0	0	0	0	0	0	0	0	1.0	0.5
SYST TIMING GEN. (TIM. MON.)	0	0	0	0	0	0	1.0	0	0	0	0	0	0	0	1.0	1.0	0	0	0	0	0	0	0	0	1.0	1.0
MORSE CODE GEN (TIM. MON.)	0	0	0	0	0	0	1.0	0	0	0	0	0	0	1.0	0	0	0	0	0	0	0	0	0	0	1.0	0
AUX/ID ADD PAR. GEN (TIM. MON.)	0	0	0	0	0	0	1.0	0	0	0	0	0	0	0	0	1.0	0	0	0	0	0	0	0	0	1.0	1.0
MONITOR DECODE (TIM. MON.)	0	0	0	0	0	0	1.0	0	0	0	0	0	0	0	1.0	1.0	0	0	0	0	0	0	0	0	1.0	1.0
MONITOR DECISION (TIM. MON.)	0	0	0	0	0	0	1.0	0	0	0	0	0	0	0	1.0	1.0	0	0	0	0	0	0	0	0	1.0	1.0
MONITOR CNTRL (ROLLO)	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.2	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.1	0.1	0.5	0.5	0.6
MONITOR TIMING BD (ROLLO)	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
SCAN TIMING BD (ROLLO)	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
EXEC INT. BD (ROLLO)	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0	0	0	0	0	0	0	0	0	0	1.0	0
MAINT INT. BD (ROLLO)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0	1.0
ANAL. COMP. BD (ROLLO)	0	0	0.1	0.1	0.1	0.1	0	0	0	0	0	0	0	0	0	0	0.1	0.1	0	0	0	0.1	0.1	0	1.0	1.0
DIG. COMP BD (ROLLO)	0.3	0.3	0	0	0	0	0	0.3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1.0	1.0
DISC. DATA BD (ROLLO)	0	0	0	0	0	0	0.1	0	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0	0	0.1	0.1	0.1	0	0	0.1	1.0	1.0
FAR FIELD ANT (RF MON)	1.0	1.0	1.0	0	0	0	1.0	0	0	0	0	0	0	0	1.0	1.0	0	0	0	0	0	0	0	0	1.0	1.0
OMNI DET (RF MON)	0	0	0	1.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1.0	0
RSLS DET & ANT (RF MON)	0	0	0	0	0	1.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1.0	0
LSLS DET & ANT (RF MON)	0	0	0	0	1.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1.0	0
TEST PULSE LOGIC (RF MON)	0	1.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1.0	0
ANGLE LOGIC (RF MON)	1.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1.0	0
SCAN SWITCH (ANT)	1.0	1.0	1.0	0	0	0	0	0	1.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1.0	0
SCAN MOD. (ANT)	1.0	1.0	1.0	0	0	0	0	0	1.0	1.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1.0	0
LENS (ANT)	1.0	1.0	1.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1.0	0
OMNI ANT (ANT)	0	0	0	1.0	0	0	1.0	0	0	0	0	0	0	0	1.0	1.0	0	0	0	0	0	0	0	0	1.0	1.0
AUX DATA INPUT	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1.0	0	0	1.0	0	0	0	0	0	0	1.0

FIGURE C.19. MONITOR EFFECT MATRIX

C.3.3.3 Analysis Conclusions

The overall conclusion of the analysis is that the monitor hardware is adequate for detecting the vast majority of system failures. During the analysis one undetectable failure was defined. This is a scan switch failure, whereby a failure of a port to close will not be detected. The effect of this failure is transmission of erroneous angle data. The discovery of this undetected failure mode will precipitate an investigation during the next contract phase.

C.3.4 HUMAN FACTORS AND SAFETY EVALUATION

A human factors and safety evaluation was performed on the MLS ground equipment to verify adherence to the design criteria in MIL-STD-1472A and the safety and grounding requirements of FAA-G-21001/b and amendment B. A checklist procedure had previously been established for performing the evaluation; a copy of the procedure is contained in Supplement B of this document.

The checklist sheets in Supplement B show the results of the evaluation. Both the Basic Narrow and the Small Community Configurations were considered in the evaluation. The checklist sheets are applicable to both systems with the exception of the Facility-Shelter-Work Station Checklist for the electronic shelter. The latter is applicable only to the Basic Narrow Configuration.

C.3.4.1 Human Factor/Safety Analysis Results

The results of the analysis indicate a system and equipment design with a close adherence to the program Human Factors and Safety criteria. A minimum amount of deviations were discovered, all minor in nature, which are described in the individual checklist sheets.

SUPPLEMENT A

MAINTAINABILITY PREDICTION FORM

Task Classification 1

Equipment Group Shelter Electronics Unit/Part Modules/Boards

Method of Isolation Monitor Panel Isolates malfunction to the LRU

MAINTENANCE ANALYSIS
1. Check monitor panel to isolate to LRU 2. Open Unit - open drawer, remove rfi cover 3. Remove and replace LRU 4. Check monitor to verify that problem is corrected 5. Close Unit - replace rfi cover, close drawer

CHECKLIST SCORES

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	Total
A	4	0	4	4	4	4	4	4	4	4	4	2	0	4	4	50
B	4	4	4	4	4	4	4									28
C	4	4	4	4	4	4	4	4	4	4						40

Predicted downtime 10 Min.

MAINTAINABILITY PREDICTION FORM

Task Classification 2

Equipment Group Shelter Electronics Unit/Part Modules/Boards

Method of Isolation Monitor Panel Localizes to Unit; Internal lights and/or Test points Localize to board.

MAINTENANCE ANALYSIS
1. Check monitor panel to Localize to unit 2. Open Unit - open drawer, remove rfi cover 3. Localize to board group with internal lights (groups - 1 to 6 boards) a) Isolate to individual board with test points, if desired 4. Remove and replace board(s) 5. Check monitor to verify that problem is corrected 6. Close Unit - replace rfi cover, close drawer

CHECKLIST SCORES

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	Total
A	4	0	4	4	4	4	2	2	2	4	4	2	0	4	4	44
B	2	4	4	4	4	4	4									26
C	4	4	4	4	2	2	2	4	4	4						34

Predicted downtime 19 Min.

MAINTAINABILITY PREDICTION FORM

Task Classification 3

Equipment Group Shelter Electronics Unit/Part Chassis Parts

Method of Isolation Monitor panel localizes to unit; test point isolates to chassis; detailed troubleshooting to faulty part.

MAINTENANCE ANALYSIS
1. Check monitor to localize to unit 2. Open Unit - open drawer, remove rfi cover 3. Check board test points a) All board test points good - begin chassis troubleshooting b) One or more board test points show faulty - remove and replace boards. If problem isn't corrected - begin chassis troubleshooting. 4. Troubleshoot to find part 5. Remove and replace part - mechanical and soldering operations 6. Check monitor to verify that problem *is rectified* 7. Close Unit - replace rfi cover, close drawer

CHECKLIST SCORES

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	Total
A	4	0	4	0	0	0	2	2	0	0	4	4	0	4	4	28
B	1	4	4	4	4	4	4									25
C	4	4	2	4	0	2	1	3	0	2						22

Predicted downtime 70 Min.

MAINTAINABILITY PREDICTION FORM

Task Classification 4

Equipment Group Antenna Enclosure Unit/Part Power Supplies

Method of Isolation Monitor Panel isolates malfunction to the LRU

MAINTENANCE ANALYSIS

1. Check monitor to isolate to the LRU
2. Go to antenna enclosure and remove cover (snap locks)
3. Check power supply test point to verify failure is not in the line
4. Remove and replace LRU
5. Check test point to verify failure removed
6. Close cover
7. Return to shelter - check monitor to verify problem has been corrected

CHECKLIST SCORES

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	Total
A	4	4	4	4	4	0	4	4	4	4	4	4	4	4	4	56
B	4	4	4	4	4	4	4									28
C	2	4	4	4	4	4	4	4	4	4						38

Predicted downtime 8 Min.

Plus 2 minutes to walk to antenna enclosure and back 10 Min.

MAINTAINABILITY PREDICTION FORM

Task Classification 5

Equipment Group Antenna Enclosure **Unit/Part** Boards/Switches

Method of Isolation Monitor panel localizes to steering or switches: local monitor and/or test points isolate to faulty LRU

MAINTENANCE ANALYSIS
1. Check monitor to localize to unit 2. Go to antenna enclosure and remove cover (snap locks) 3. Check local monitor and/or test points to isolate to LRU 4. Remove and replace LRU 5. Check test points and/or local monitor to verify failure removed 6. Close enclosure cover 7. Return to shelter - check monitor to verify problem has been corrected

CHECKLIST SCORES

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	Total
A	4	4	4	4	4	2	2	2	2	4	4	2	0	4	4	46
B	2	4	4	4	4	4	4									26
C	2	4	4	4	2	2	2	4	4	4						32

Predicted downtime 18 Min.

Plus 2 minutes to walk to antenna enclosure and back 20 Min.

MAINTAINABILITY PREDICTION FORM

Task Classification 6

Equipment Group Antenna Enclosure Unit/Part RF Cables

Method of Isolation Monitor panel localizes to antenna equipment; local monitoring and/or test points isolates to r.f. cables

MAINTENANCE ANALYSIS
1. Check monitor to localize to unit - no switches show malfunction 2. Go to antenna enclosure and remove cover (snap locks) 3. Check local monitor and test points to verify it's not one of the boards or switches 4. Isolate to faulty cable 5. Remove and replace cable 6. Check local monitor to verify failure removed 7. Go to shelter to verify field monitor indicates failure removed 8. Return to antenna enclosure and close cover

CHECKLIST SCORES

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	Total
A	4	4	4	0	4	2	0	0	0	0	0	4	0	4	4	30
B	1	4	4	4	4	4	4									25
C	2	4	2	4	0	2	1	3	0	2						20

Predicted downtime 65 Min.

Plus 3 minutes walking between shelter and enclosure 68 Min.

MAINTAINABILITY PREDICTION FORM

Task Classification 7

Equipment Group Shelter Electronics **Unit/Part** Cooling Fan

Method of Isolation Hear that fan motor is inoperating.

MAINTENANCE ANALYSIS

1. Check power to motor - presence of power shows motor is bad
2. Turn off power
3. Remove and replace cooling fan assembly
4. Restore power

CHECKLIST SCORES

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	Total
A	4	0	4	2	2	2	4	2	3	0	4	4	4	0	4	39
B	2	4	4	4	4	4	4									26
C	3	4	2	3	3	4	4	4	4	4						35

Predicted downtime 24 Min.

BASIC NARROW

UNIT	FAILURE RATE (FAIL/10^6 HRS)	QTY.	PERCENT OF TOTAL FR	TASK CLASS	MTTR CONTRIBUTION (MIN.)
TWT AMP	61.917	2	16.62	1	1.66
RF ASSY CHASSIS PARTS	3.682	1	0.49	3	0.34
EXCITER	11.646	2	3.13	2	0.59
ISOLATOR	0.767	2	0.21	3	0.15
DPSK ASSY	2.679	2	0.72	1	0.07
VAR. ATTEN.	0.852	2	0.23	3	0.16
AMPLITUDE MODULATOR	9.023	2	2.42	1	0.24
LC/STATUS CHASSIS PARTS	37.065	1	4.98	3	3.49
SYSTEM SYNC AZ	0.658	1	0.09	2	0.02
SYSTEM SYNC EL	1.585	1	0.21	2	0.04
DATA LINK BOARD	1.836	2	0.49	2	0.09
DATA LINK AUX DATA	1.762	1	0.24	2	0.05
VARIABLE AUX DATA GEN	1.707	1	0.23	2	0.04
FIXED AUX DATA #2	2.122	1	0.29	2	0.06
FIXED AUX DATA #1	2.122	1	0.29	2	0.06
AUX DATA SEL/WORD VER.	1.314	1	0.18	2	0.03
AUX ID/ADDRESS/PARITY GEN	1.616	2	0.43	2	0.08
MORSE CODE GEN.	1.365	2	0.37	2	0.07
ID/BASIC DATA/DPSK	1.656	4	0.89	2	0.17
SYSTEM TIMING GEN, AZ	2.133	2	0.57	2	0.11
SYSTEM TIMING GEN, EL	2.128	2	0.57	2	0.11
SEQUENCE TIMER	1.833	2	0.49	2	0.09

BASIC NARROW

UNIT	FAILURE RATE ($FAIL/10^6$ HRS)	QTY.	PERCENT OF TOTAL FR	TASK CLASS	MTTR CONTRIBUTION (MIN.)
TIMING CONTROL, AZ	5.543	1	0.75	2	0.14
TIMING CONTROL, EL	7.350	1	0.99	2	0.19
LC/STATUS INDICATOR	2.000	2	0.54	3	0.38
10 MHz DRIVER	0.052	2	0.01	2	0.01
10 MHz OSCILLATOR A	3.393	2	0.91	2	0.17
LIGHT DRIVER/ALARM	1.860	2	0.50	2	0.09
EXECUTIVE INTEGRATOR	2.302	7	2.16	2	0.41
MONITOR CONTROL	1.118	2	0.30	2	0.06
DPSK DECODER	1.065	2	0.29	2	0.06
DPSK DECISION	3.052	2	0.82	2	0.16
DISCRETE DATA BOARD	0.972	2	0.26	2	0.05
ANALOG COMP. #3	2.364	2	0.64	2	0.12
ANALOG COMP. #2	2.287	2	0.61	2	0.12
MAINTENANCE INTEGRATOR	2.200	6	1.77	2	0.34
MAINTENANCE MONITOR INDICATOR	7.800	2	2.09	2	0.40
RECLOCK DRIVER	0.531	2	0.14	2	0.03
MONITOR TIMING	1.825	2	0.49	2	0.09
SCAN TIMING	16.593	2	4.46	2	0.85
ANALOG COMP. #1	2.352	2	0.63	2	0.12
DETECTOR COMPARATOR	0.894	2	0.24	2	0.05
BEAM ACCURACY COUNTER AZ	5.185	1	0.69	2	0.14
BEAM ACCURACY COUNTER EL	4.657	1	0.63	2	0.13

BASIC NARROW

UNIT	FAILURE RATE ($FAIL/10^6$ HRS)	QTY.	PERCENT OF TOTAL FR	TASK CLASS	MTTR CONTRIBUTION (MIN.)
DIGITAL COMPARATOR	10.435	2	2.80	2	0.53
FREQ MONITOR	3.448	2	0.93	2	0.18
TIMING REFERENCE	0.759	1	0.10	2	0.02
MAINT. MON. CHASSIS PARTS	6.537	1	0.88	3	0.62
MONITOR PWR SUPPLY CHASSIS PARTS	11.361	1	1.53	3	1.07
C-BAND L.O.	11.646	2	3.13	2	0.59
RF MODULE	19.979	2	5.36	2	1.02
REGULATOR/BUFFER	0.877	2	0.24	2	0.05
MIXER	0.907	2	0.24	2	0.05
5 V, 10 A PWR. SUPPLY	1.198	5	0.80	1	0.08
15 V, 1.5 A PWR. SUPPLY	1.293	4	0.70	1	0.07
20 V, 1 A PWR. SUPPLY	0.754	2	0.20	1	0.02
5 V, 5 A PWR. SUPPLY	0.604	3	0.24	1	0.02
PWR SUPPLY ASSY, CHASSIS PARTS	4.011	1	0.54	3	0.38
COOLING FAN	6.005	2	1.61	7	0.39
SCAN SWITCH	2.381	20	6.39	5	1.28
SCAN MODULATOR	8.841	2	2.37	4	0.24
ANT. SELECTOR SWITCH AZ	1.056	1	0.14	2	0.03
ANT. SELECTOR SWITCH EL	1.217	1	0.16	2	0.03
PWR DIST. BOX PARTS	13.360	1	1.79	3	1.25
LIGHTNING PROTECTOR BD #1 A	1.798	1	0.24	2	0.05
LIGHTNING PROTECTOR BD #1 B	1.798	2	0.48	2	0.09

BASIC NARROW

UNIT	FAILURE RATE (FAIL/10^6 HRS)	QTY.	PERCENT OF TOTAL FR	TASK CLASS	MTTR CONTRIBUTION (MIN.)
LIGHTNING PROTECTOR BD #1 C	1.857	1	0.25	2	0.05
LIGHTNING PROTECTOR BD #1 D	2.997	2	0.80	2	0.15
LIGHTNING PROTECTOR BD #1 E	0.619	1	0.08	2	0.02
LIGHTNING PROTECTOR BD #2 A	1.239	2	0.33	2	0.06
LIGHTNING PROTECTOR BD #2 B	1.425	1	0.19	2	0.04
LIGHTNING PROTECTOR BD #2 C	1.319	1	0.18	5	0.04
LIGHTNING PROTECTOR BD #4 A	4.833	1	0.65	2	0.12
LIGHTNING PROTECTOR BD #4 B	4.333	1	0.58	2	0.11
LIGHTNING PROTECTOR BD #5 A	5.281	1	0.71	5	0.14
LIGHTNING PROTECTOR BD #5 B	5.269	1	0.71	5	0.14
LIGHTNING PROTECTOR BD #3	0.918	2	0.25	2	0.05
BEAM STEERING CHASSIS PARTS	10.871	1	1.46	6	0.99
SCAN CONTROL	2.510	2	0.67	5	0.13
SCAN CONTROL COMPARATOR	1.946	2	0.52	5	0.10
SCAN SWITCH DRIVER	1.537	1	0.21	5	0.04
SCAN SWITCH DRIVER INTERMEDIATE	2.076	1	0.28	5	0.06
10 MHz OSCILLATOR B	2.641	2	0.71	5	0.14
SCAN CONTROL MONITOR	2.661	2	0.72	5	0.14
SCAN SWITCH MONITOR	2.810	2	0.75	5	0.15
SCAN SWITCH MONITOR EXPANDER	4.333	1	0.58	5	0.12
SCAN SWITCH MONITOR INTERMEDIATE	2.034	1	0.27	5	0.05
ANT. P.S. ASSY CHASSIS PARTS	0.164	1	0.02	6	0.01

BASIC NARROW

UNIT	FAILURE RATE ($FAIL/10^6$ HRS)	QTY.	PERCENT OF TOTAL FR	TASK CLASS	MTTR CONTRIBUTION (MIN.)
24 V, 1.0 A POWER SUPPLY	0.627	2	0.17	4	0.02
40 V, 0.5 A POWER SUPPLY	0.720	2	0.19	4	0.02
AZIMUTH APERTURE ASSY PARTS	0.010	1	0.01	6	0.01
VIDEO AMP A	0.177	6	0.14	2	0.03
VIDEO AMP B	0.230	2	0.06	5	0.01
DETECTOR	1.199	14	2.25	3	1.58
TERMINATION	0.852	6	0.69	3	0.48
DIRECTION CPLR	0.010	2	0.01	3	0.01
BANDPASS FILTER	0.629	2	0.17	3	0.12
PWR DIV.	0.943	2	0.25	3	0.18
MON ANT MISC PARTS	0.539	1	0.07	6	0.05
			100.00		25.25

SMALL COMMUNITY

UNIT	FAILURE RATE (FAIL/10^6 HRS)	QTY.	PERCENT OF TOTAL FR	TASK CLASS	MTTR CONTRIBUTION
TWT AMP	71.419	2	13.55	1	1.36
RF ASSY CHASSIS PARTS	3.682	1	0.35	3	0.25
EXCITER	13.173	2	2.50	2	0.48
DPSK ASSEMBLY	3.598	2	0.68	1	0.07
AMPLITUDE MODULATOR	10.723	2	2.03	1	0.20
ISOLATOR	0.767	2	0.15	3	0.11
RF ATTENUATOR	0.852	2	0.16	3	0.11
TERMINATION	2.558	2	0.49	3	0.34
DETECTOR	1.294	15	1.84	3	1.29
LC/STATUS CHASSIS PARTS	54.622	1	5.18	3	3.63
SYSTEM SYNC, AZ	2.256	1	0.21	2	0.04
SYSTEM SYNC, EL	5.139	1	0.49	2	0.09
DATA LINK	5.805	2	1.10	2	0.21
MORSE CODE GENERATOR	4.326	2	0.82	2	0.16
ID/BD/DPSK	4.547	4	1.73	2	0.33
SYSTEM TIMING GEN, AZ	7.059	2	1.34	2	0.25
SYSTEM TIMING GEN, EL	7.006	2	1.33	2	0.25
TIMING CONTROL, AZ	10.184	1	0.97	2	0.18
TIMING CONTROL, EL	11.404	1	1.08	2	0.21
10 MHz DRIVER	0.282	2	0.05	2	0.01
10 MHz OSCILLATOR	3.393	2	0.64	2	0.12
SEQUENCE TIMER	5.241	2	0.99	2	0.19

SMALL COMMUNITY

UNIT	FAILURE RATE (FAIL/10^6 HRS)	QTY.	PERCENT OF TOTAL FR	TASK CLASS	MTTR CONTRIBUTION
LIGHT DRIVER/ALARM	4.326	2	0.82	2	0.16
LC/STATUS INDICATOR	2.000	2	0.38	3	0.27
MAINTENANCE MONITOR CHASSIS PARTS	14.122	1	1.34	3	0.94
EXECUTIVE INTEGRATOR	7.169	8	5.44	2	1.03
MONITOR CONTROL	2.604	2	0.49	2	0.09
DPSK DECODE	3.061	2	0.58	2	0.11
DPSK DECISION	5.882	2	1.12	2	0.21
DPSK DATA	2.110	2	0.40	2	0.08
RECLOCK DRIVER	1.795	2	0.34	2	0.06
MONITOR TIMING	5.571	2	1.06	2	0.20
SCAN TIMING	19.708	2	3.74	2	0.71
ANALOG COMPARATOR #3	7.599	2	1.44	2	0.27
ANALOG COMPARATOR #1	7.338	2	1.39	2	0.26
ANALOG COMPARATOR #2	7,594	2	1.44	2	0.27
DETECTOR/COMPARATOR	2.942	2	0.56	2	0.11
BEAM ACCURACY COUNTER AZ	9.240	1	0.88	2	0.17
BEAM ACCURACY COUNTER EL	6.882	1	0.65	2	0.12
DIGITAL COMPARATOR	12.902	2	2.45	2	0.47
FREQUENCY MONITOR	7.874	2	1.49	2	0.28
TIMING REFERENCE	2.509	2	0.48	2	0.09
MONITOR PWR. SUPPLY CHASSIS PARTS	11.131	1	1.06	3	0.74
C-BAND LO	13.173	2	2.50	2	0.48

SMALL COMMUNITY

UNIT	FAILURE RATE (FAIL/10^6 HRS)	QTY.	PERCENT OF TOTAL FR	TASK CLASS	MTTR CONTRIBUTION
RF MODULE	27.436	2	5.21	2	0.99
REGULATOR/BUFFER	1.055	2	0.20	2	0.04
MIXER	0.907	2	0.17	2	0.03
MON. PWR SUPPLY PWR DIVIDER	1.174	1	0.11	3	0.08
MON. PWR SUPPLY TERMINATION	2.949	1	0.28	3	0.20
5 V, 9 A POWER SUPPLY	1.197	4	0.45	1	0.05
±15 V, 2 A POWER SUPPLY	2.492	2	0.47	1	0.05
5 V, 12 A POWER SUPPLY	1.204	2	0.23	1	0.02
±15 V, 0.7 A POWER SUPPLY	2.494	2	0.47	1	0.05
40 V, 0.35 A POWER SUPPLY	1.462	2	0.28	1	0.03
24 V, 0.7 A POWER SUPPLY	1.107	2	0.21	1	0.02
20 V, 0.9 A POWER SUPPLY	1.194	2	0.23	1	0.02
PWR SUPPLY ASSY CHASSIS PARTS	4.750	1	0.45	3	0.32
BEAM STEERING CHASSIS PARTS	13.462	1	1.28	3	0.90
SCAN CONTROL	7.294	2	1.38	2	0.26
SCAN CONTROL COMPARATOR	3.617	2	0.69	2	0.13
SCAN CONTROL MONITOR	7.635	2	1.45	2	0.28
SCAN SWITCH MONITOR	6.231	2	1.18	2	0.22
B.S. 10 MHz OSCILLATOR	2.641	2	0.50	2	0.10
SCAN SWITCH	1.488	8	1.13	5	0.23
SCAN MODULATOR	30.158	2	5.72	4	0.57
ANT. SELECT SWITCH	1.269	3	0.36	5	0.07

SMALL COMMUNITY

UNIT	FAILURE RATE (FAIL/10^6 HRS)	QTY.	PERCENT OF TOTAL FR	TASK CLASS	MTTR CONTRIBUTION
ANT. PWR SUPPLY CHASSIS PARTS	0.164	1	0.02	3	0.01
PWR DIST. ASSY PARTS	8.886	1	0.84	3	0.59
MAINTENANCE INTEGRATOR	6.446	6	3.67	2	0.70
MAINTENANCE MONITOR INTEGRATOR	8.400	2	1.59	2	0.30
MON. ANT BOX ASSY, PARTS	4.979	1	0.47	3	0.33
LIGHTNING PROT. BOARD #1 A	1.798	1	0.17	2	0.03
LIGHTNING PROT. BOARD #1 B	3.095	1	0.29	2	0.06
LIGHTNING PROT. BOARD #2	1.319	1	0.13	2	0.02
LIGHTNING PROT. BOARD #5 A	5.269	1	0.50	2	0.10
LIGHTNING PROT. BOARD #5 B	5.281	1	0.50	2	0.10
LIGHTNING PROT. ASSY	0.918	2	0.17	2	0.03
VIDEO AMP A	0.807	9	0.69	2	0.13
VIDEO AMP B	0.987	5	0.47	2	0.09
MON. ANT BANDPASS FILTER	0.629	2	0.12	3	0.08
MON. ANT. DIVIDER	0.943	2	0.18	3	0.13
DIRECTION COUPLER	0.010	2	0.01	3	0.01
			100.00		24.37

SUPPLEMENT B

HUMAN FACTORS AND SAFETY
EVALUATION CHECKLISTS
FOR
MLS GROUND EQUIPMENT

1.0 INTRODUCTION

This document describes a method for evaluating the extent to which Human Factors and Safety Engineering criteria have been designed into the equipment. The method described utilizes a series of checklists which have been prepared, to digest and summarize the design criteria given in MIL-STD-1472A. Specifically for the MLS application, two additional checklists have been prepared for the safety and grounding requirements given in FAA-G-2100 1/b and amendment B, attachment I.

Tabulation forms are also provided so that the numerous factors involved can be systematically applied in the evaluation of the hardware. The forms also provide a written record of the results of the evaluation, including specific comments and recommendations.

2.0 DESCRIPTION OF CHECKLISTS

So that the user may have an overview of the evaluation procedure, an outline of the checklists, showing their organization into groups, is provided and described.

The checklists are grouped into three major categories according to their applicability to specific hardware features. The first group of checklists relates to the evaluation of control and display panel layout. The second group is to be used for the evaluation of workspace and environment related criteria. The third group relates to hardware factors other than panel layout and workstation design.

Some of the factors are duplicated in several of the checklists (e.g. under labeling or safety). However, there is no duplication in the evaluation procedure itself, since the duplicated factors apply to different aspects of the hardware design, which should be evaluated separately and independently.

There is duplication, however, between some of the factors in the safety checklist R (MIL-STD-1472A) and checklist S (FAA-G-2100 1/b). Rather than merge the two checklists, they are kept separated so that the FAA-G-2100 requirements can be independently identified, and can be deleted from evaluations for which they are not applicable.

Group I - Panel Layout Checklists

A. Control - Display Integration
B. Visual Displays (general criteria)
C. Transilluminated Displays
D. Scale Indicators
E. Other Visual Displays
F. Auditory Displays
G. Controls
H. Labeling

Group II - Facility, Shelter, Workstation Checklists

I. Anthropometry
J. Workspace
K. Console Design
L. Stairs, Ramps, Ladders, Doors, Hatches
M. Environment
N. Trailers, Vans, Enclosures
O. Safety

Group III - Equipment Checklists

P. Maintainability
Q. Labeling
R. Safety
S. Safety (FAA-G-2100 1/b)
T. Grounding (FAA-G-2100 1/b)

3.0 USE OF CHECKLISTS AND TABULATION FORMS

A separate tabulation form is provided for each of the three checklist groups so that each may be evaluated independently as is applicable to the specific hardware and/or hardware level.

In using the various forms, a separate form should be completed for each item under evaluation, as applicable. For example, in an equipment console with five unit drawers, a separate panel form should be completed for each unit front panel that has controls or displays in sufficient number to warrant a detailed human factors evaluation. Similarly, each of the drawers might warrant separate evaluation for the Group III criteria (especially if each drawer is designed by a different subcontractor). Where uniform design criteria have been employed throughout all drawers, one Group III form might be applicable for the entire console. Separate Group II forms should be prepared for each work station (whether seated or standing) and for the general work area, facility and/or shelter.

In all of the checklists, each of the factors is expressed as a question. If the answer to the question is a yes, a "check" is placed into the appropriate box. This check implies that the human factors/safety criterion expressed by the factor is satisfied without qualifications.

If the criterion is not satisfied, or if the criterion is satisfied with certain qualifications, then a "C" (for comments) is placed into the appropriate box. The evaluation of all factors scored with a "C" should be elaborated upon under the comments section. Where the criterion is evaluated as satisfied with qualifications, such qualifications should be delineated. Where the criterion is evaluated as not being satisfied, the comments should indicate the specific reasons for the evaluation along with suggested recommendations. (Note: such recommendations might include "no change." Where such a recommendation

is given, the reasons why this recommendation is made should be given.)

If the factor is not applicable to the particular design, an "N" is placed into the appropriate box. Placing an N into the box, instead of leaving it blank, provides a positive record of all of the factors that were included in the evaluation and states that, in the evaluator's opinion, these factors were not applicable.

GROUP I - PANEL LAYOUT CHECKLISTS

CHECKLIST A - CONTROL-DISPLAY INTEGRATION

1. Relationship - is the relationship between a control and its associated display apparent from the use of proximity, grouping, coding, framing, labeling or similar design techniques?
2. Precision - is the precision of control manipulation consistent with the precision required by the display? Conversely, is the precision of the display presentation consistent with the range of control movement?
3. Feedback - adequate feedback provided on control response?
4. Functional Grouping - are functionally related controls and displays located in proximity to one another, arranged in groups by sequence, frequency of use or importance?
5. Borders - where appropriate, are borders used to designate functional groups?
6. Movement - are the movement of display indicators sufficiently clear and unambiguously direct to guide the appropriate control response?
7. Time Lag - has time lag or inertia between control movement and display presentation been eliminated or minimized?
8. Direction - in both controls and displays, do movements which are clockwise, forward, up or to-the-right represent an increase in setting magnitude?
9. Control-Display Ratio - has the control-display ratio been selected to minimize the total time required to make the desired control movement?

CHECKLIST B - VISUAL DISPLAYS

1. Information Content - is the displayed information limited in content to that which is required to perform specific actions or to make decisions?

2. Precision - is the information displayed only to the degree of precision required for a specific action or decision?
3. Format - is the information displayed in directly usable form (no transposing, interpolating, computing, etc.)?
4. Display Failures - are display failures immediately apparent as display failures?
5. Failsafe - are display circuits designed so that display failures do not cause equipment failures?
6. Unrelated Markings - are markings, such as trademarks or company names, which are not related to the panel function eliminated from the panel face?
7. Location - are displays located so that they may be read to the precision required by personnel in the normal operating position?
8. Access - can displays be read without the use of ladders, supplementary lighting, or other special equipment?
9. Orientation - are display faces perpendicular to the operator's normal line of sight, wherever feasible? If not normal, is the display face greater than the minimum 45° from the normal line of sight?
10. Reflectance - are displays constructed, arranged and mounted to minimize the reflectance of ambient illumination?
11. Vibration - has display vibration been eliminated so that operator performance is not degraded below required levels?
12. Grouping - are displays logically grouped according to their sequence of use, functional relations, frequency of use and importance?
13. Importance - are critical displays placed in privileged positions in optimum visual zones or otherwise highlighted?

14. Minimum Viewing Distance - is the minimum viewing distance greater or equal to 13 inches?
15. Maximum Viewing Distance - for displays associated with local controls, is the viewing distance within the maximum reach distance of 28 inches?

CHECKLIST C - TRANSILLUMINATED DISPLAYS

1. Equipment Response - do lights display equipment response and not merely control position?
2. Positive Feedback - is the "lamp on" position used to denote a positive indication of the condition sought? (e.g. go-ahead, ready, malfunction.)
3. Grouping - are master caution, master warning, and summation lights set apart from component status lights?
4. Location - are critical function indicators located within 15^{o} of the operator's normal line of sight?
5. Maintenance Displays - on units having operator displays, are maintenance displays located behind access doors?
6. Brightness - are displays within the range of 10% to 300% brighter than the surrounding brightness?
7. Reflections - are provisions made to prevent direct or reflected sunlight from making indicators appear illuminated?
8. Brightness Control - for applications with varied ambient brightness, is a variable control provided?
9. Lamp Redundancy - except for airborne applications, are incandescent bulbs redundant?
10. Lamp Test - is a lamp test provided on panels with greater than three bulbs?
11. Lamp Removal - where possible, are provisions made to remove incandescent bulbs from the front of the display without tools and while power is applied?

12. Color Coding - do colors conform to applicable specifications? (Where unspecified, do they conform to MIL-C-25050?)
13. Legend Lights - are legend lights used in preference to simple indicator lights to the maximum extent practical?
14. Transilluminated Panel Assemblies - are panel assemblies which present whole patterns of information applicable? (Suitable for presentation of data flow and complicated data organization.)

CHECKLIST D - SCALE INDICATORS

1. Selection - except where necessitated by operational restrictions, are moving-pointer, fixed-scale indicators selected in preference to fixed-pointer, moving scale indicators?
2. Linearity - are non-linear scales avoided except where system requirements dictate nonlinearity?
3. Scale Markings - are scale graduations multiples of 1, 2, or 5? Is the number of intermediate markings less than nine?
4. Contrast - is the contrast between the scale face and the markings at least 50%.
5. Coding - is the face of the scale coded (pattern and/or color) to indicate ranges, zones, operating levels, etc?
6. Numerical Progression - does the numerical progression increase as the scale is read clockwise, from left to right or from bottom to top?
7. Orientation - are scale numerals upright when in the reading position?
8. Zero Position in Fixed Circular Scales - when positive and negative values are displayed around a zero or a null position, is the null point located at either 12 o'clock or at 9 o'clock? Are positive values represented by clockwise pointer motion?

9. Null Indicators - is the circuit designed so that, if power fails, the indicator will NOT rest in the in-tolerance position?

10. Fixed-Pointer, Moving-Scale Indicators - should be avoided. Where required, is the unused portion of the dial face covered in applications requiring the setting of a value? For tracking applications, is the whole dial face exposed?

CHECKLIST E - OTHER VISUAL DISPLAYS

1. CRT Size - are the signal size and CRT display size consistent with the computations resulting from the requirements of 20 minutes of visual angle?
2. CRT Viewing Distance - is a 16 inch viewing distance provided? Does the design permit the observer to view the scope from as close as he may wish? Are displays which must be viewed from distances greater than 16 inches appropriately modified?
3. CRT Brightness - does ambient illumination contribute less than 25% of screen brightness?
4. Faint Signals - are hoods or shields provided for CRT when the ambient illumination is above 0.25 FT-C?
5. Reflected Glare - is the scope placement, relative to light sources, selected to minimize reflected glare?
6. Adjacent Surfaces - are surfaces adjacent to the scope of a dull matte finish? Do they have a brightness range between 10% and 100% of the screen background brightness?
7. Counter Mounting - are mechanical counters mounted as close as possible to the panel surface to minimize parallax?
8. Counter Movement - is the movement of mechanical counters snap action rather than continuous? Does a clockwise rotation of the reset knob increase the indication?

9. Printer Format - is printed information presented in directly usable form?
10. Printer Supplies - are printers designed for quick insertion and removal of printing materials? Is a take-up device provided? Is there a positive indication of remaining supply?
11. Annotation - are printers mounted so that tapes may be annotated easily while still in the recorder?
12. Plotter Contrast - where plotters are used is a minimum of 50% contrast provided between the plotted function and the background?
13. Job Aids - are aids (e.g. graphic overlays) provided when an operator is required to interpret graphic data?
14. Flags - is the use of flags restricted to non-emergency conditions? Do they operate by snap action? Is a minimum of 50% contrast provided between the flag and its background? Does a malfunction flag at least partially obscure the operator's view of the normal display? Is a flag test provided?

CHECKLIST F - AUDITORY DISPLAYS

1. Application - are auditory displays provided in situations with any of the following conditions?
   a. The information is short, simple and transitory and requies immediate or time-based response.
   b. Visual display is restricted by overburdening, illumination, operator mobility, degradation of vision by reason of vibration, high g-forces, hypoxia, or other environmental factors; or anticipated operator inattention.
   c. To warn, alert or cue the operator to subsequent additional response, or the criticality of response.
   d. Custom or usage has created anticipation of display.
   e. Voice communication is necessary or desirable.

2. Type - are the application of tones and non-periodic complex sounds restricted to status indication?
3. False Alarms - are false alarms minimized or precluded in the design?
4. Circuit Test - are circuitry test devices provided?
5. Caution Signals - are caution signals readily distinguishable from warning signals?
6. Relation to Visual Displays - when used with visual displays, are auditory signals used to supplement or support the visual display?
7. Frequency - is the frequency of the tone between 250 and 2500 hertz?
8. Intensity - is the sound pressure level at least 20 dB above the maximum ambient noise level?
9. Headsets - are headsets provided where ambient noise will exceed 100 dB?
10. Discriminability - where several different auditory signals are used, are they readily discriminable through the use of differences in pitch, intensity, beats, harmonics and/or coding?
11. Prohibited Types of Signals - are prohibited types of signals avoided? (Prohibited signals are those which might be confused with sounds or noises which are likely to occur under normal operating conditions. These signals include tones resembling navigation signals or coded radio transmissions, static, electrical interference, bfo glissandi, cross modulation, random noise, bagpipes, etc.)
12. Compatibility - is the meaning of the audio warning signal compatible with established meanings?
13. Masking - are means provided to prevent audio warning signals from interfering with other critical functions or warning signals?

14. Verbal Warnings - is the voice used distinctive and mature? Is the delivery formal, impersonal and calm? Is the message content intelligible, apt and concise?
15. Controls for Auditory Warning Devices - are persistent signals provided with a shut-off (automatic or manual) control, and a volume control? Is automatic reset provided? Are volume controls restricted to prevent reducing the volume to an inaudible level?

CHECKLIST G - CONTROLS

1. Selection - has the selection of types of controls considered, as applicable, distribution of load (overburdening of operator's limbs), multirotation for precision over wide ranges, detents for discrete functions?
2. Sequential Operations - where sequential operations follow a fixed pattern, are the controls arranged to facilitate the operation?
3. Coding - where applicable, are controls coded by labeling, location, shape, size and/or color for differentiation?
4. Accidental Activation - are controls designed and located to minimize their susceptibility to accidental activation without precluding normal operation within the required time?
5. Dead Man Controls - are dead man controls utilized wherever operator incapacity can produce a critical condition?
6. Concentric Shafts - for concentric shaft vernier controls is the larger diameter knob used for the fine adjustment? Are the knobs adequately coded to avoid confusion?
7. Spacing - are minimum separation requirements between controls met?

AD-A081 133 BENDIX CORP BALTIMORE MD COMMUNICATIONS DIV F/G 17/7
MICROWAVE LANDING SYSTEM (MLS). PHASE III (BASIC NARROW AND SMA--ETC(U)
JAN 78 DOT-FA72WA-2801
UNCLASSIFIED MLS-BCD-R-2801-1-VOL-2 NL

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8. Rotary Controls - do rotary switches have a moving pointer and a fixed scale? Except where shape coding is used and torque is light, are the knobs bar shaped? Do blind switches have no more than 12 positions? Are visible switches limited to 24 positions? Are stops provided where ranges are applicable?
9. Thumb Wheels - is color coding used to facilitate checking of off and normal positions? Can the readout be viewed from all operator positions? In non-detented switches is a resistance provided?
10. Knobs - are knobs used where little force is required and precise adjustments of a continuous variable are required? Is a moving knob with fixed scale employed?
11. Pushbuttons - are pushbuttons used for momentary contact or for locking circuitry? Is the button surface either concave or a nonslip surface? Is there a positive indication of activation (tactual, click, lamp, etc.)?
12. Toggle Switches - are toggle switches of three or more positions avoided? Are the switches oriented vertically with down representing "off"?
13. Legend Switches - is there a positive indication of switch activation? Is the legend legible with only one lamp operating? Are the lamps replaceable from the front? Is there a maximum of three lines of lettering on the legend plate?
14. Other Controls - are cranks, handwheels, levers or pedals provided, as applicable, for tasks requiring many rotations, large forces, multidimensional movements or large displacement?

CHECKLIST H - PANEL LABELING

1. Label Characteristics - do the labels provide for accurate identification of required functions at the

working distance required with the availabe illumination in the time available for recognition and reponse? Is the criticality of the function labeled or coded?

2. Orientation - are labels oriented horizontally so that they may be read quickly and easily? Where the use of vertical labeling cannot be avoided because of space limitations, is its use restricted to non-critical functions?
3. Abbreviations - are standard abbreviations employed?
4. Qualities - are the labels brief, visible, legible, unobscured, of high contrast? Do they use words familiar to the operator?
5. Label Characters - do the characters conform to MIL-M-18012? Is the ratio of letters to reading distance between 0.4% and 1.0% (For illumination levels below 1 foot lambert the ratio shall be increased by 50%). Is a 5/3 aspect ratio used? Is the stroke width 1/6 of the height?
6. Functional Labeling - is each control and display labeled according to function, avoiding similar names for different controls and displays? Does the label reflect the function being measured or controlled? Does the label indicate the functional result of control movement (e.g. increase)? Where control and displays are used together, do the labels indicate their functional relationship?
7. Location - does the location of the label give priority to ease of operation over label visibility? Are labels located above the control and displays they describe? (Except where visibility will be enhanced by locating the label below the control...e.g. eye level or higher.) Are the units of measurement located on the panel? Are labels identifying functionally grouped controls and/or displays provided? Are such labels located above the functional group identified and centered?

8. Size Graduation - to reduce confusion and search time, are labels graduated in size with group controls labeled with larger characters than individual controls, and with size graduations decreasing down to individual control position labels? Has the size of the smallest characters been determined by the viewing distance criteria? Is each size graduation approximately 25% larger than the next smaller size?

HUMAN FACTORS ENGINEERING
PANEL LAYOUT CHECKLIST

EQUIPMENT ____________ SHELTER ____________ CABINET ____________

UNIT ____________ EVALUATOR ____________ DATE ____________

CHECKLIST	FACTOR														
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
A															
B															
C															
D															
E															
F															
G															
H															

(√ - SATISFACTORY; C - REFER TO COMMENTS; N - NOT APPLICABLE)

CHECKLIST ITEM	COMMENTS	RECOMMENDATIONS

GROUP II - FACILITY, SHELTER, WORK STATION CHECKLISTS

CHECKLIST I - ANTHROPOMETRY

1. Gross Dimensions - do gross dimensions of passageways, accesses, clearances, etc. permit the passage of the body or parts of the body based upon the 95th percentile values of applicable body dimensions?
2. Limiting Dimensions - are limiting dimensions (such as reach distance, control movements, etc.) which restrict or are limited by body extension based upon the 5th percentile values of applicable body dimensions?
3. Adjustable Dimensions - do the dimensions of adjustable devices (seats, safety belts, goggles, etc.) span a range sufficient to accommodate the 5th through the 95th percentile values of applicable body dimensions?
4. Use of Dimension Data - in selecting the design-critical dimensions, does the design allow for the nature, frequency and difficulty of the tasks?
5. Body Position - has the position of the body during performance of the task been allowed for in the design dimensions?
6. Flexibility - has mobility and flexibility requirements imposed by required tasks been included in design-critical dimensions?
7. Obstacles - have increments in design-critical dimensions been included to account for the need to compensate for obstacles, projections, garments, packages, lines, padding, etc?

CHECKLIST J - WORK SPACE CHECKLIST

1. Kick Space - do all cabinets, consoles and work surfaces that require an operator to stand or sit close to the front surface contain a minimum kickspace of 4 inches deep and 4 inches high?

2. Handles - are handles on cabinets and consoles either recessed to eliminate projections or designed so they will neither injure personnel nor entangle clothing or equipment?

3. Work Space - a free floor space of at least 4 feet in front of each console is desirable. Where maintenance is required, are the following minimum work spaces provided?
   a. Depth of work area - 42 inches minimum between the rack and the opposite surface or obstacle.
   b. Lateral work space - (for racks with drawers) -
      1. Drawers weighing less than 45 pounds - 18 inches on one side, 4 inches on the other.
      2. Drawers weighing over 45 pounds - 18 inches on each side.
   c. Storage space - adequate and suitable for manuals, worksheets, and other operational or maintenance materials.

4. Work Surfaces (standing) - are work surfaces for standing operations 36 inches above the standing surface? (unless otherwise specified in the contract).

5. Display Placement (standing) - for standing operations, are displays mounted on vertical panels placed in an area between 41 and 74 inches above the floor? Are displays requiring frequent and/or precise readings placed in an area between 50 and 69 inches above the standing surface?

6. Control Placement (standing) - for standing operations, are controls mounted on vertical panels located in an area between 34 and 74 inches above the standing surface? Are controls requiring frequent, and/or precise operation and emergency controls located in an area between 34 and 57 inches above the standing surface and no further than 22 inches laterally from the centerline?

7. Work Surfaces (seated) - for seated operations, are work surfaces at least 30 inches wide by 16 inches deep? Are desk tops and writing tables placed 30 inches above the floor? Are writing surfaces on equipment consoles at least 16 inches deep by 23 inches wide?
8. Seating - are seats adjustable, vertically, from 16 to 23 inches in increments of no more than one inch? Is a backrest provided that reclines between 103° and 115°? Where applicable, is at least one inch of cushioning provided on both the seat and the backrest? Are 2 x 8 inch armrests provided?
9. Knee Room - for seated operations, is knee and foot room provided that equals or exceeds 25 inches in height, 20 inches in width and 18 inches in depth?
10. Display Placement (seated) - for seated operations, are displays mounted on vertical panels located between 6 and 48 inches above the sitting surface? Are displays requiring frequent and/or precise readings placed between 14 and 37 inches above the sitting surface and no further than 22 inches laterally from the centerline? Are critical warning displays mounted at least 22.5 inches above the sitting surface on consoles requiring horizontal vision over the top?
11. Control Placement (seated) - for seated operations, are controls mounted on vertical panels located between 8 and 35 inches above the sitting surface? Are controls requiring frequent and/or precise operation mounted between 8 and 30 inches above the sitting surface.
12. Unusual Positions - does the work space design for work to be accomplished in unusual positions (squatting, stooping, kneeling, crawling, or prone) conform to the appropriate preferred dimension? Do all clearance dimensions provide no less than the minimum values specified?

CHECKLIST K - CONSOLE DESIGN

1. Dimensions - do the dimensions of standard console designs conform to the dimensions given in Table VII of MIL-STD-1472A?
2. Configurations - are standardized console configurations employed wherever feasible?
3. Variables - have the following variables been considered in choosing the most appropriate console design?
   a. visibility over the top of the console.
   b. operator mobility requirements.
   c. panel space requirements.
   d. volume required below the writing surface.

Where special purpose console designs are required, the following checklist items apply:

4. Panel width - for panel widths exceeding 44 inches, is a flat-surface, segmented, wrap-around console provided so that all controls are within the reach of a 5th percentile operator?
5. Dimensions - where vision over the top is not required, is the width of the control segment kept to within 34 inches? Are the left and right segments no more than 24 inches wide?
6. Viewing Angle - is the total left-to-right viewing angle kept to below 190°?
7. Vertical Panel Division - where forward vision is not required and lateral space is limited, is the panel divided into three vertical/stacked segments with surfaces perpendicular to the operator's line of sight with little or no head movement?
8. Vertical Segment Height - where vertical/stacked segments are used, is the center of the central segment 31.5 inches above the seat reference point? Is the height of this segment limited to 21 inches?

CHECKLIST L - STAIRS, LADDERS, RAMPS, DOORS, HATCHES

1. Selection - does the selection of stairs, stair-ladders, fixed ladders or ramps conform to the angle of ascent requirements of MIL-STD-1472A?
2. Hand-carrying of Equipment - are ramps or elevators provided when equipment weighing more than 40 pounds must be hand carried? Are stairs or steps provided rather than ladders in any application requiring hand-carrying of equipment under 40 pounds?
3. Handrails and Guardrails - are handrails provided on each side of stairs, stair-ladders, fixed ladders and ramps? Where one or both sides are open, are intermediate guardrails provided?
4. Stairs - are stair dimensions within the maxima or minima specified in Figure 26?
5. Stair Ladders - are stair ladder dimensions within the minima or maxima of Figure 27? Is the tread rise open at the rear? Are landings provided every tenth or twelth tread? Is the tread surface either of open grating material or treated with nonskid material? Are they of metal construction? Do handrails have non-slip surfaces?
6. Fixed Ladders - are ladder dimensions within the maxima or minima of Figure 28? Are ladders providing access to multiple levels offset at each level? Is a guardrail provided at the opening at the top of each fixed ladder? Is safety caging provided on fixed ladders more than 20 feet high?
7. Ramps - where cleating is required for pedestrian ramps, are the cleats spaced 14 inches apart? Do they extend from handrail to handrail at right angles to the line of traffic? Where vehicular and pedestrian traffic must be mixed on one ramp, is the vehicular surface located in the center of the ramp, with pedestrian traffic next to the handrails?

8. Platforms - are platform surfaces constructed of open metal grating or treated with non-skid material? Do open sides have guardrails not less than 42 inches high (with intermediate rails) and a toeboard or guard screen not less than 3 inches high? Are hand holds provided where needed.

9. Elevators, Inclinators, Hydraulic Platforms - are the following items and devices provided?
   a. maximum load signs.
   b. control guards to prevent accidental operation.
   c. limit stops.
   d. a fail-safe brake or other self-locking device.
   e. provision for manually lowering the platform, where feasible.
   f. for open platforms - see the factors under platforms.

10. Doors - when a sliding door is used, is a separate hinged door in the sliding door provided for personnel exit? Is fixed equipment at least 3 inches from the swept area of hinged doors?

11. Hatches - are wall hatches flush with the floor, where possible? Do hatches open with a single hand or foot motion? Is the unlocking force for handles less than 20 pounds? Can overhead hatches be opened with less than 50 pounds force?

12. Hatch Dimensions - do hatches accommodate limiting dimensions for location and operability and gross dimensions for size and passage? (Including any requirements for carrying equipment through the hatch.) Do rectangular hatches conform to Figure 29 of MIL-STD-1472A? Is the minimum diameter of circular hatches 30 inches? Are appropriate foot rests or steps provided where a step-down through a top access exceeds 27 inches?

CHECKLIST M- ENVIRONMENT

1. Heating - is heating provided in mobile personnel enclosures capable of at least 50°F? For semi-permanent facilities, is the heater capable of at least 68°F?
2. Ventilation - does the ventilation system provide a minimum of 30 cfm per man? Is approximately 2/3 of the ventilation from outside air? Is the air flow moving past the man kept below 100 cfm (65 cfm preferred)?
3. Air Conditioning - is air conditioning provided for enclosures with effective temperatures exceeding 85°F? Is the air conditioning system designed so that cold-air discharge is not directed on personnel?
4. Humidity - is the humidity value approximately 45% @ 70°F? Are provisions made to prevent the humidity from decreasing below 15%?
5. Temperature Uniformity - is the difference in air temperature from floor to ceiling within 10°F?
6. Thermal Tolerance - is the combined temperature-humidity exposure within the prescribed tolerance limits (when corrected for air flow rates)?
7. Illumination - is the illumination at the prescribed levels for the required tasks? Is the illumination distributed to reduce glare and specular reflection?
8. Hazardous Noise - is noise generated by equipment kept below the maximum allowable levels prescribed by applicable specifications? Is noise generation and penetration controlled to the extent that acoustic energy will not cause personnel injury, interfere with voice or other communications, cause fatigure or in any other way degrade over-all system effectiveness?
9. Speech Interference - are the facility and equipment noise controlled to levels that will permit the necessary voice communications as determined by applicable measures? (Articulation index, speech interference levels, and/or noise criteria).

10. Facility Design - does the design of the facility control the noise level to the optimum extent feasible through effective sound reduction and attenuation techniques?
    a. Attenuation - sound absorbing materials for floors, walls, ceilings; staggered walls, staggered doors, double-paned windows, baffles.
    b. Reverberation time - is reverberation time reduced to the limits given in Figure 35 of MIL-STD-1472A?
    c. Absorption Coefficient - is the sound absorption coefficient at least 0.2, but less than 0.5?
11. Vibration - are the facility and equipment designed to control the transmission of whole body vibrations to levels consistent with comfort, proficiency and safety limits? Are equipment vibrations below levels which impair control manipulation or display readability?

CHECKLIST N- TRAILERS, VANS AND TRANSPORTABLE ENCLOSURES

1. Brake Controls - are trailer brake controls located so that an operator can reach them while restraining or positioning the trailer manually? Are the controls located on the side away from road traffic?
2. Positioning Controls - are trailers equipped with precise positioning controls when the trailer must mate parts?
3. Landing Gear Lock - can the landing gear lock and release be operated by either the hand or the foot?
4. Vans and Enclosures - do vans and transportable enclosures which serve as shelters for men and equipment and which require recurring occupany in excess of one hour meet the following criteria?
    a. ceiling height - minimum of 78 inches.
    b. personnel access (doors) - minimum of 76 inches high by 30 inches wide.

c. equipment access openings - as appropriate and convenient.

d. steps, stairs or ladders - provided for van floors more than 18 inches above ground level.

e. access doors - capable of being locked in open as well as closed positions, and provided with inner releases.

CHECKLIST O - SAFETY

1. Safety Labels and Placards - are conspicuous placards mounted adjacent to any hazardous equipment? Are jacking and hoisting points labeled? Are areas requiring special protective clothing specifically identified? Are "NO-STEP" markings provided? Are receptacles marked, as appropriate, with voltage, phase and frequency characteristics? Are pipe, hose and tube lines clearly labeled or coded? Are floor openings properly marked?
2. Fire Extinguishers - are fire extinguishers of the correct type readily accessible? Are they located where fires will not block access to them?
3. Alerting Devices - is a hazard alerting device provided? Is the sound distinctly recognizable and unlikely to be masked by other noises?
4. Emergency Exits - are emergency exits readily accessible, unobstructed and quick opening (5 seconds or less)?
5. Obstructions - are walkways, steps and work areas well designed and free of dangerous projections and/or obstructions?
6. Illumination - is adequate illumination provided in all areas? Are warning placards, stairways and all hazardous areas particularly well illuminated?
7. Energy Sources - are energy sources isolated?
8. Antenna Range - is there an antenna microwave radiation hazard zone? Is it clearly marked and guarded?

9. Safety Mesh - is a screen or safety mesh installed on the underside of open gratings, platforms or flooring surfaces where there is a possibility that small tools or parts may fall through on workers or equipment beneath the grating?

HUMAN FACTORS ENGINEERING

FACILITY-SHELTER-WORK STATION CHECKLIST

EQUIPMENT ______________ SHELTER ____________________ CABINET AREA ____________

EVALUATOR ______________________ DATE ______________

CHECKLIST	FACTOR											
	1	2	3	4	5	6	7	8	9	10	11	12
I												
J												
K												
L												
M												
N												
O												

(√ - SATISFACTORY; C - REFER TO COMMENTS; N - NOT APPLICABLE)

CHECKLIST ITEM	COMMENTS	RECOMMENDATIONS

GROUP III - EQUIPMENT/UNIT CHECKLISTS

CHECKLIST P - MAINTAINABILITY

1. Special Tools - are special tools, required for operational adjustments, securely mounted in a readily accessible location within the equipment?
2. Clothing Constraints - where applicable, does the design permit installation, removal and maintenance by personnel wearing required special purpose clothing or equipment?
3. Mounting of Parts - are parts mounted on a two-dimensional surface rather than stacked? Are similarly formed components mounted in a standard orientation? Are delicate components either located or guarded to reduce damage susceptibility?
4. Adjustments Controls - are knobs, rather than screw-driver adjustments employed for frequently adjusted controls? Are reference scales or other feedback provided for all adjustments? Are limit stops on calibration or adjustment controls provided, where required? Are sensitive adjustments located or guarded to avoid inadvertent disturbance? Are screwdriver shaft guides provided where adjustments must be made without the aid of vision?
5. Accessibility - are structural members located so that parts, components and replaceable items can be removed without difficulty? Are sliding, rotating or hinged units, to which rear access is required, free to open or rotate to their full distance? Are braces, gravity or other means provided to hold hinged assemblies open or in the "out" position while being worked on?
6. Lubrication - can mechanical components requiring it, be lubricated without disassembly? Are extended fittings provided to lubricate parts not readily visible or accessible? Are labels provided which specify lubrication type and frequency?

7. Cases and Covers - are edges and corners rounded or otherwise finished to prevent injury? Are cases designed to be lifted from units rather than units lifted from cases? Is the case size large enough to avoid damage to wire or parts when cases are put on or removed? Are guides, tracks, slides or stops provided, as necessary, to prevent injury to personnel or damage to units? Is it obvious when a cover, which is in place, is not secured? Can covers be removed without interference from bulkheads, brackets or other units?
8. Access Openings - are covers for access openings either completely removable or self-supporting in the open position? Are labels provided identifying accessible items, recommended procedures, and/or hazards? Are arm and hand access openings large enough to not only permit the required operation but, where possible, provide an adequate view of the manipulated parts? Is an interlock provided on the access cover where hazardous voltages exist?
9. Fasteners - are captive bolts and nuts used in situations where dropped items might cause damage to equipment or create a difficult or hazardous removal problem? Are captive fasteners provided for access covers requiring periodic removal?
10. Unit Handling - are rests or stands provided, where feasible? (Including space for tools and test equipment.) Are irregular, fragile, or awkward extensions (cables, wave guides, hoses, etc.) designed for easy removal before handling?
11. Weight - are the unit weight vs height requirements within the maximum limits of Table XVII of MIL-STD-1472A? Are labels provided for items weighing more than the one-man lift values? Where mechanical or power lift is required are hoist and lift points provided and clearly labeled?

12. Handles and Grasp Areas - are all removable units provided with handles or other suitable means for grasping, handling and carrying? Wherever possible, are handles located relative to the center of gravity of the unit to preclude swinging or tilting? Are handles located to provide at least 2 inches of clearance from obstructions during handling? Do foldout handles have a stop in open position? Can they be opened with one hand? Do handles meet the dimension requirements of Figure 30 of MIL-STD-1472A?
13. Mounting - can units be removed along a straight line (or slightly curved line) rather than through an angle? Are rollout racks, slides or hinges provided on units frequently pulled out from installed positions? Are consoles or cabinets bolted down where rollout racks may cause the entire console to tip over? Are limit stops provided on racks and drawers? Are interlocks provided, where applicable? Are braces provided to hold hinged units in the "out" position?
14. Connector Spacing - are connectors spaced far enough apart to permit firm grasping for connecting and disconnecting? Is a minimum of 1 inch spacing provided? (except where a line of connectors are always removed sequentially.)
15. Test Points - are test points located close enough to associated controls so that the displayed signals can be read?
16. Test Equipment - does portable test equipment weigh under 25 pounds if it is to be carried by one man? Does the test equipment have built-in storage space for leads, probes, manuals and/or special tools?
17. Failure Indication - is an indication of prime power failure provided? Are labels provided indicating fuse ratings? Can fuses be readily replaced? Are displays

provided to indicate if equipment has failed? Is an auditory alarm provided (where applicable) to indicate a critical malfunction?

CHECKLIST Q - LABELING

1. Label Characteristics - do the labels provide for accurate item identification at the required working distance, with the available illumination in the time available for recognition? Is there consistency in label design within and between systems?
2. Label Characters - do the characters conform to MIL-M-18012? Is the ratio of height of letters to reading distance between 0.4% and 1.0%? (For illumination levels below 1 foot lambert the ratio shall be increased by 50%). Is a 5/3 aspect ratio used? Is the stroke width 1/6 of the height?
3. Assemblies, Components, Parts - is each assembly, component and part labeled clearly and visibly with a readable, meaningful name, number or symbol?
4. Location - are the gross identifying labels on assemblies or major components located externally in position not obscured by adjacent assemblies or components? Are they located on the flattest, most uncluttered surface available? Are they located on the main equipment chassis?
5. Life - are labels located in a way to minimize wear or obscurement by grease, grime or dirt? Is accidental removal, obstruction or handling damage precluded?
6. Terms - are components, circuits or assemblies labeled with terms descriptive of the test or measurement applicable to their test points? (e.g. demodulator rather than crystal detector.)

CHECKLIST R - SAFETY

1. Warning Placards - are conspicuous placards mounted adjacent to any equipment which presents a hazard to personnel? (e.g. high voltage, high frequency, hot equipment, where mechanical components (linkages, springs, etc.) are under constant load or strain, noxious gases, moving parts, jacking and hoisting points, liquid, gas and steam pipelines, and radiation.) Are the center of gravity and/or the weight distinctly marked on equipment, as applicable?
2. Hazardous Locations - is the placement of internal controls near hazardous locations avoided? (e.g. high voltages, rotating machinery or hot parts.) Where such location cannot be avoided, are appropriate shields and labels provided?
3. Interlocks and Alarms - does the operation of a switch or control which initiates a hazardous operation (e.g. movement of a crane) require the prior operation of a related or locking control? Where practical, is a visual or auditory warning device activated?
4. Access - are parts which retain heat or electrical potential after equipment is turned off located so that they will not be touched during normal maintenance? Are discharge or bleeder devices provided for high-energy capacitors? Are covers, structural members, etc., either grounded or protected? Are struts and latches provided to keep hinged and sliding components from shifting? Do drawers and fold-out assemblies have limit stops? Are safety interlocks used in high voltage distribution circuitry?
5. Edge Rounding - are exposed edges rounded to a minimum radius of 0.04 inches, and exposed corners to a minimum of 0.5 inches? if not rounded, are they protected by rubber, fiber or plastic?

6. General Electrical Hazards - are wires routed so that removal of a plug or connector will not expose "hot" leads? Are tools and test leads adequately insulated? Are plugs and receptacles designed to preclude the insertion of a plug or one voltage into the receptacle of another voltage? Are all external parts (except antennas and transmission lines) grounded? Do electrical hand-tools have three-wire power cords or double insulation?
7. Mechanical Hazards - are guards provided on all moving parts of machinery including pulleys, belts, gears, blades, etc., on which personnel may become injured or entangled? Are all mechanical components with heavy springs designed so the spring cannot come loose? Is adequate clearance for fingers provided in the design of telescoping steps or ladders?
8. Toxic Hazards - are personnel exposed to toxic hazards in excess of established threshold limit values?

CHECKLIST S - FAA-G-2100/1b SAFETY REQUIREMENTS

1. Line-input Terminals - do all ac line-input terminals (120V ac or higher) have covers, barriers or guards?
2. Interlocks - are interlocks provided for all voltages of 150V or higher which would otherwise be accessible while primary doors, covers, or shields are removed? Are assemblies or chassis at voltages of 500V and higher completely enclosed and separately interlocked?
3. Interlock Switches - are interlock switches normally open, momentary on, with a manual latch for on position? Does the switch automatically return to momentary-on upon reclosing the cover? (Cutler-Hammer Part 8909, Type K128, DPST, 6A/250V, 12A/125V; Cutler-Hammer #91820X1F1, DPST, 10A/250V, 15A/125V; or equiv.) Are interlock bypass switches provided? (A combination interlock/bypass switch may be used.)

4. X-RAY - is x-radiation from high power tubes, radars, transmitters, CRT's, kept within the exposure limit of 2 mil-roentgens per hour through the use of shields, interlocks, etc?
5. Discharging Devices - are automatic protective methods and/or devices provided to discharge high voltage circuits and capacitors to 30 volts or less, within 2 seconds after power is removed or an interlock opened?
6. Cathode Ray Tubes - are provisions incorporated to protect personnel from CRT implosion? (safety glass, laminated face plates, reinforecement, warning signs.)
7. Radioactive Material - have radioactive luminescent markings and paints been prohibited?
8. Warning Signs - are all contacts, terminals, parts, etc., having voltages in excess of 500 volts clearly marked? Are exposed dangerous rotating and reciprocating mechanical parts provided with warning signs? Are the signs located conspicuously, and as close as possible to the point of danger?
9. Test Points & Controls - are test points and controls located so as to preclude accidental shock? (In no case shall they be located in compartments with voltage points of 500 volts or higher.)
10. Noise Levels - are the noise levels generated by the equipment within the limits specified in paragraph 1-3.5.11 of FAA-G-2100/1b?

CHECKLIST T - FAA-G-2100/1b GROUNDING REQUIREMENTS

1. Grounding Practices - are at least four separate grounding networks, each isolated from each other, provided? (AC ground, chassis/cabinet ground, signal ground, trunk circuit ground.)
2. Power Supply Returns - are metallic circuits (wires) used for power supply returns? Are power supply returns as close as physically possible to the "hot" wire to reduce ground loops? Are power supply outputs isolated from each other? Are common returns avoided?

3. Single Point Grounding - where electronic loads are referenced to ground, are power supply outputs left ungrounded so that reference to ground is at the load termination only? (For multiple loads ground only once at the point of maximum use.) Are d.c. distribution systems grounded only at the source (generator) with ungrounded return circuits provided for all distribution?
4. Shielded Wire - are outer conductors of shielded wire avoided as signal or power returns?
5. Ground Impedance - is the ground impedance between any two points within a cabinet kept below one milli-ohm?
6. Splices & Connectors - are splices in copper ground busses either welded or brazed? (Bolted bus splices are not be be solely relied on.) In making ground connections, is the joining of dissimilar metals avoided? Is adequate environmental protection provided to minimize accelerated joint corrosion?
7. RF Grounds - are copper sheets or straps used for R.F. grounds? (Braided or stranded conductor shall not be used.) To minimize RF impedance, are the ground conductors kept as short as is physically possible?
8. Cabinet Bus - are all chassis, nests, racks, panels and cabinet subassemblies positively grounded to the cabinet bus with a minimum wire size of AWG #16?
9. Primary Power - are the grounding systems for primary power kept separate from equipment ground systems? (A single point reference of the two ground systems is permissible.)
10. Building Structures - is the equipment grounding system kept isolated from building structures except for bonding at one point only? (Where metal frames or enclosures require grounding for safety reasons, direct equipment ground connections to building structures are permitted.)

11. <u>Conduits</u> - are conduits properly bonded to the equipment services by either bond strap or brazing, etc.?
12. <u>Air Ducts</u> - are all air ducts (and sections) electrically bonded to building ground?
13. <u>Cable Trays</u> - are all cable trays bonded to an appropriate ground by either bond strap, welding, brazing, etc.?
14. <u>Machinery</u> - is all rotating machinery (including electric motors, generators, fans, etc.) properly grounded with the necessary precautions taken to reduce interference.
15. <u>Unit Frames</u> - does the unit frame ground system provide only a single path back to architectural ground for all points in each subsystem?

HUMAN FACTORS ENGINEERING
EQUIPMENT/UNIT CHECKLISTS

EQUIPMENT ____________ SHELTER ____________ CABINET ____________

UNIT ____________ EVALUATOR ____________ DATE ____________

CHECKLIST	FACTOR																
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
P																	
Q																	
R																	
S																	
T																	

(√- SATISFACTORY; C - REFER TO COMMENTS; N - NOT APPLICABLE)

CHECKLIST ITEM	COMMENTS	RECOMMENDATIONS

HUMAN FACTORS ENGINEERING

PANEL LAYOUT CHECKLIST

EQUIPMENT MLS AZ & EL SHELTER Elec. Shelter CABINET Elec. Cab.

UNIT TWT AMP PANEL EVALUATOR Mihm DATE 7/21/77

CHECKLIST	FACTOR														
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
A	✓	✓	✓	✓	✓	N	✓	N	✓						
B	✓	✓	✓	C	✓	✓	✓	✓	✓	✓	N	✓	✓	✓	✓
C	✓	✓	N	✓	N	✓	✓	N	N	C	N	✓	✓	N	
D	N	N	N	N	N	N	N	N	N	N					
E	N	N	N	N	N	N	N	N	N	N	N	N	N	N	
F	✓	N	N	N	N	N	N	N	N	N	N	N	N	N	N
G	✓	✓	✓	✓	N	N	✓	N	N	N	N	✓	✓	N	
H	✓	✓	✓	✓	✓	✓	✓	✓							

(✓- SATISFACTORY; C - REFER TO COMMENTS; N - NOT APPLICABLE)

CHECKLIST ITEM	COMMENTS	RECOMMENDATIONS
B4 & C10	Except for the two fault lights, it is obvious when the light is inoperable since the lights are related to an operational control. The fault light indications are remoted to the back of the unit allowing for future remoting to the maint. mon. panel.	Remote the fault indications to the maint. mon. panel for redundancy.

HUMAN FACTORS ENGINEERING
PANEL LAYOUT CHECKLIST

EQUIPMENT MLS AZ & EL SHELTER Elec. Shelter CABINET Elec. Cab.

UNIT Local Cntrl/Status Panel EVALUATOR Mihm DATE 7/22/77

CHECKLIST	FACTOR														
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
A	✓	✓	✓	✓	✓	✓	✓	✓	✓						
B	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	N	✓	✓	✓	✓
C	✓	✓	N	✓	N	✓	✓	N	N	✓	N	✓	✓	N	
D	✓	N	N	✓	N	N	N	N	N	N					
E	N	N	N	N	N	N	N	N	N	N	N	N	N	N	
F	✓	✓	✓	✓	N	N	✓	✓	N	N	✓	✓	✓	N	✓
G	✓	✓	✓	✓	✓	N	✓	✓	N	✓	N	✓	✓	N	
H	✓	✓	✓	✓	✓	✓	✓	✓							

(✓ - SATISFACTORY; C - REFER TO COMMENTS; N - NOT APPLICABLE)

CHECKLIST ITEM	COMMENTS	RECOMMENDATIONS

HUMAN FACTORS ENGINEERING
FACILITY-SHELTER-WORK STATION CHECKLIST

EQUIPMENT MLS AZ & EL Basic Narrow Only SHELTER Elec. Shelter CABINET AREA All

EVALUATOR Mihm DATE 7/25/77

CHECKLIST	FACTOR											
	1	2	3	4	5	6	7	8	9	10	11	12
I	✓	✓	N	✓	✓	✓	✓					
J	✓	✓	C	✓	C	C	N	N	N	N	N	✓
K	N	N	N	N	N	N	N	N				
L	✓	N	✓	✓	✓	N	N	N	N	N	N	N
M	✓	✓	✓	✓	✓	✓	✓	N	N	N	N	
N	N	N	N	N								
O	✓	✓	N	✓	✓	✓	✓	N	N			

(✓ - SATISFACTORY; C - REFER TO COMMENTS; N - NOT APPLICABLE)

CHECKLIST ITEM	COMMENTS	RECOMMENDATIONS
J3	Only 3.1' have been provided for work area depth in the Basic Narrow Shelter instead of the recommended 3.5'.	No recommendations. The required shelter dimensions necessitate this exception. Also, the deviation is slight.
J5-J6	Pwr supply panels, containing a minimum of lights and toggle controls are lower than 41" off the floor. This has been covered on checklist item B9 and C4 of the power supply panel layout checklist.	Refer to power supply panel layout checklist, B9 and C4.

HUMAN FACTORS ENGINEERING

PANEL LAYOUT CHECKLIST

EQUIPMENT MLS AZ & EL SHELTER Elec. Shelter CABINET Elec. Cab.

UNIT Power Supply Panel EVALUATOR Mihm DATE 7/25/77

CHECKLIST	FACTOR														
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
A	✓	✓	✓	✓	✓	✓	✓	✓	✓						
B	✓	✓	✓	✓	✓	✓	✓	✓	C	✓	N	✓	✓	✓	✓
C	✓	✓	✓	C	N	✓	✓	N	N	N	✓	✓	✓	N	
D	N	N	N	N	N	N	N	N	N	N					
E	N	N	N	N	N	N	N	N	N	N	N	N	N	N	
F	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
G	✓	N	✓	✓	✓	N	✓	N	N	N	N	✓	✓	N	
H	✓	✓	✓	✓	✓	✓	✓	✓							

(✓- SATISFACTORY; C - REFER TO COMMENTS; N - NOT APPLICABLE)

CHECKLIST ITEM	COMMENTS	RECOMMENDATIONS
B9 & C4	The panel is located close to the floor and display is therefore >45° from line of sight. This is necessary since this chassis is heavy. Also, the quantity of controls and indicators is minimum on this panel. Lamp type indicators (no meters) only, are on this panel. This configuration is SOP for power supply panels.	This configuration is satisfactory and therefore no recommendations are in order. (Note that those panels containing the greatest quantity of controls and indicators are around eye level.)

HUMAN FACTORS ENGINEERING

PANEL LAYOUT CHECKLIST

EQUIPMENT MLS AZ & EL SHELTER Elec. Shelter CABINET Elec. Cab.

UNIT Maint. Mon. Panel EVALUATOR Mihm DATE 7/25/77

CHECKLIST	FACTOR														
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
A	✓	✓	✓	✓	✓	N	N	N	N						
B	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	N	✓	N	✓	✓
C	✓	✓	N	✓	N	✓	✓	N	N	✓	N	✓	✓	N	
D	N	N	N	N	N	N	N	N	N	N					
E	N	N	N	N	N	N	N	N	N	N	N	N	N	N	
F	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
G	✓	N	✓	✓	✓	N	✓	N	N	N	N	✓	✓	N	
H	✓	✓	✓	✓	✓	✓	✓	C							

(✓ - SATISFACTORY; C - REFER TO COMMENTS; N - NOT APPLICABLE)

CHECKLIST ITEM	COMMENTS	RECOMMENDATIONS
H8	There are up to four levels of labeling. Due to this fact and the quantity of labels on this panel, it is impossible to comply with the size gradation rqmt. and at the same time make all labels large enough. This is not considered critical due to the non-critical nature of this panel.	This is an acceptable deviation.

HUMAN FACTORS ENGINEERING
PANEL LAYOUT CHECKLIST

EQUIPMENT MLS AZ & EL SHELTER Elec. Shelter CABINET Elec. Cab.

UNIT MON. PWR. SUPP. PANEL EVALUATOR Mihm DATE 7/25/77

CHECKLIST	FACTOR														
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
A	✓	✓	✓	✓	✓	N	✓	✓	✓						
B	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	N	✓	N	✓	✓
C	✓	✓	✓	✓	N	✓	✓	N	N	N	✓	✓	✓	N	
D	N	N	N	N	N	N	N	N	N	N					
E	N	N	N	N	N	N	N	N	N	N	N	N	N	N	
F	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
G	✓	N	✓	✓	✓	N	✓	N	N	N	N	✓	N	N	
H	✓	✓	✓	✓	✓	✓	✓	✓							

(✓- SATISFACTORY; C - REFER TO COMMENTS; N - NOT APPLICABLE)

CHECKLIST ITEM	COMMENTS	RECOMMENDATIONS

HUMAN FACTORS ENGINEERING
EQUIPMENT/UNIT CHECKLISTS

EQUIPMENT MLS AZ & EL SHELTER Elec. Shelter CABINET Elec. Cab.

UNIT All Drawers EVALUATOR Mihm DATE 7/26/77

CHECKLIST	FACTOR																
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
P	N	N	✓	✓	✓	N	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Q	✓	✓	✓	✓	✓	✓											
R	✓	✓	✓	✓	✓	✓	N	✓									
S	✓	✓	✓	✓	✓	N	N	✓	✓	✓							
T	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	N	N	N	✓		

(✓- SATISFACTORY; C - REFER TO COMMENTS; N - NOT APPLICABLE)

CHECKLIST ITEM	COMMENTS	RECOMMENDATIONS

HUMAN FACTORS ENGINEERING
PANEL LAYOUT CHECKLIST

EQUIPMENT MLS AZ & EL SHELTER Elec. Shelter CABINET Elec. Cab.

UNIT RF UNIT PANEL EVALUATOR Mihm DATE 7/27/77

CHECKLIST	FACTOR														
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
A	✓	✓	✓	✓	✓	✓	✓	✓	✓						
B	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
C	N	N	N	N	N	N	N	N	N	N	N	N	N	N	
D	N	N	N	N	N	N	N	N	N	N					
E	N	N	N	N	N	N	N	N	N	N	N	N	N	N	
F	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
G	✓	N	✓	✓	N	N	✓	N	N	✓	N	N	N	N	
H	✓	✓	✓	✓	✓	✓	✓	✓							

(✓- SATISFACTORY; C - REFER TO COMMENTS; N - NOT APPLICABLE)

CHECKLIST ITEM	COMMENTS	RECOMMENDATIONS

HUMAN FACTORS ENGINEERING

PANEL LAYOUT CHECKLIST

EQUIPMENT MLS AZ & EL SHELTER Antenna Case CABINET ____

UNIT MAINT. PANEL EVALUATOR Mihm DATE 7/27/77

CHECKLIST	FACTOR														
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
A	✓	✓	✓	✓	N	✓	✓	✓	✓						
B	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	N	✓	N	✓	✓
C	✓	✓	N	N	N	✓	✓	N	N	✓	N	✓	N	N	
D	✓	✓	✓	✓	N	✓	✓	N	✓	N					
E	N	N	N	N	N	N	N	N	N	N	N	N	N	N	
F	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
G	✓	✓	✓	✓	✓	N	✓	✓	N	✓	N	✓	N	N	
H	✓	✓	✓	✓	✓	✓	✓	N							

(✓ - SATISFACTORY; C - REFER TO COMMENTS; N - NOT APPLICABLE)

CHECKLIST ITEM	COMMENTS	RECOMMENDATIONS

HUMAN FACTORS ENGINEERING
FACILITY-SHELTER-WORK STATION CHECKLIST

EQUIPMENT MLS AZ & EL SHELTER ANTENNA CASE CABINET AREA ______

EVALUATOR Mihm DATE 7/28/77

CHECKLIST	FACTOR											
	1	2	3	4	5	6	7	8	9	10	11	12
I	✓	✓	✓	✓	✓	✓	✓					
J	✓	N	✓	✓	✓	✓	N	N	N	N	N	N
K	N	N	N	N	N	N	N	N				
L	N	N	N	N	N	N	N	N	N	N	✓	✓
M	N	N	N	N	N	N	N	N	N	N	N	
N	N	N	N	N								
O	N	C	N	N	N	N	N	✓	N			

(✓ - SATISFACTORY; C - REFER TO COMMENTS; N - NOT APPLICABLE)

CHECKLIST ITEM	COMMENTS	RECOMMENDATIONS
02	No fire extinguisher in antenna enclosure. There is no personnel fire hazard since personnel cannot enter this shelter.	No recommendation.

HUMAN FACTORS ENGINEERING

EQUIPMENT/UNIT CHECKLISTS

EQUIPMENT MLS AZ & EL SHELTER ANTENNA CASE CABINET ______

UNIT ______ EVALUATOR Mihm DATE 7/29/77

CHECKLIST	FACTOR																
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
P	✓	N	✓	✓	✓	N	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Q	✓	✓	✓	✓	✓	✓											
R	✓	✓	N	✓	✓	✓	N	✓									
S	✓	✓	N	N	N	N	N	N	✓	N							
T	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	N	N	N	✓		

(√- SATISFACTORY; C - REFER TO COMMENTS; N - NOT APPLICABLE)

CHECKLIST ITEM	COMMENTS	RECOMMENDATIONS

APPENDIX D

MAINTAINABILITY

PLAN

FOR

MLS

GROUND SYSTEM

Prepared by

The Bendix Corporation
Communications Division
Towson, Maryland 21204

November 1977

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MAINTAINABILITY DEMONSTRATION PLAN
FOR THE
MLS GROUND SUBSYSTEM

D.1 SCOPE

This document describes the test procedure that will be implemented to demonstrate that the MLS Ground Subsystem is designed to meet a mean-time-to-repair (MTTR) of no greater than 0.5 hours, as specified in Table 11-6B of FAA-ER-700-07. The test procedure conforms to MIL-STD-471A, Test Method 9, for mean-corrective-maintenance-time (μ_c). The level of repair which will be demonstrated is the restoration of ground sub-system operation at the organization level of maintenance, accomplished through the replacement of line replaceable units (LRU's). Fault isolation and diagnostics are performed to a major degree using the existing monitoring circuitry and built-in-test-equipment.

D.2 APPLICABLE DOCUMENTS

The following documents of the issue in effect on the date of the contract, form a part of this test plan to the extent specified herein.

D.2.1 Standards

MIL-STD-280	Definitions of Item Levels
MIL-STD-470	Maintainability Program Requirements
MIL-STD-471	Maintainability Demonstration
MIL-STC-721	Definitions of Effectiveness Terms

D.2.2 Handbooks

MIL-HDBK-472	Maintainability Prediction

D.2.3 Other

Contract No. DOT FA72WA-2801

FAA-ER-700-07, Amendment 1, 2/25/75, revised 3/26/75. MLS Functional Requirements Specification

MLS-RM-001-IN, 11/12/75 - Reliability and Maintainability Predictions for Basic (Narrow) and Small Community Ground Subsystems.

D.3 GENERAL TEST REQUIREMENTS

D.3.1 Description of the Equipment to be Tested

The Maintainability Test will be performed on a complete MLS Phase III Basic Narrow System, less the DME equipment. Both Azimuth and Elevation subsystems will be included.

D.3.2 Demonstration Site

The maintainability demonstration will be performed at the Bendix Communications Division facility in Towson, Maryland.

D.3.3 Number and Skill Level of Repair Personnel

All maintenance tasks can be performed with one technician. The technician assigned to the demonstration will have a skill level, in Bendix's opinion, equivalent to an FAA Technician.

D.3.4 Demonstration Test Team

A demonstration test team will be organized and assembled to assure appropriate representation of FAA and Bendix personnel for accomplishing the maintainability demonstration. A Bendix test conductor will be responsible for all test activities including the supervision of those technicians involved in the insertion of simulated failures as well as those involved in performing the maintenance tasks, timing and recording the data.

D.3.5 Task Selection Method

The sample size of 200 tasks has been derived in accordance with the procedure outlined in Appendix A of MIL-STD-471A. Appendix A provides specific procedures for assuring that the corrective maintenance (CM) tasks to be used in the demonstration constitute a representative sample of the total population of CM tasks. Of the 200 tasks identified, 50 will be selected at random by the FAA representative to be used in the demonstration.

Based on the procedures of Appendix A of MIL-STD-471A, a table has been constructed which gives the distribution of tasks

resulting from the sample size analyses. This table, which may be found in Supplement 1, contains items which are grouped by module in accordance with the level of maintenance to be demonstrated. The number of tasks assigned to each item was allocated by predicted frequency of occurrence; that is, percent contribution to the overall failure rate of the unit under demonstration.

Also given in Supplement 1 is the method which will be used to randomly select the 50 demonstration tasks.

D.3.6 Data Acquisition

During the Maintainability demonstration test, a data collection method will be implemented to measure and record the elapsed time required to repair each simulated fault. The format presented in Figure D.7-2 will be used to record in minutes the time required for such specific task elements as fault location, fault correction (module removal and replacement), and final adjustment, checkout and reassembly. Supply and administrative delay time and servicing time will be excluded from all calculations of maintenance downtime.

D.3.7 Analysis of Data and Method of Scoring

Following the completion of the 50 sample tasks, mean downtime of the sample ($\bar{x}_c$) will be calculated in accordance with Test Method 9 of Appendix B in MIL-STD-471A.

Data analysis will include all of the tasks which were randomly selected and performed from the Task Identification and Location Table found in Supplement 1.

Accept/reject criteria will be computed for the specified value of MTTR at a 10% consumer's risk using the following test:

a) Mean of Sample $(\bar{x}_c) = \dfrac{\sum_{i=1}^{N_c} X_{ci}}{N_c}$

b) Accept if $MTTR_{specified} \geq \overline{X}_c + \frac{\phi\sigma}{\sqrt{N_c}}$

Reject if $MTTR_{specified} < \overline{X}_c + \frac{\phi\sigma}{\sqrt{N_c}}$

where σ = standard deviation of sample of corrective maintenance tasks

ϕ = 1.28 (consumer's risk (β) - 10%)

N_c = 50 (number of demonstrated tasks)

D.4 TEST PROCEDURES

D.4.1 Periodic Checks

Prior to the insertion of each fault to be simulated, the equipment involved will be checked to assure that no real fault exists. These checks will be as indicated in paragraph D.4.2 below. After fault insertion, the equipment will be rechecked to determine that the malfunction has been properly installed and that no other malfunction exists. In addition, a check will be made after the fault has been removed to be sure that the equipment has been properly restored. Results of each check will be entered, as appropriate, in a General Test Log (See Figure D.7-1).

D.4.2 Check-Out Procedure

D.4.2.1 Unit Level Checks

Checks will be made on individual units prior to the insertion of a fault, and after its removal. These checks will be to simply determine that the unit is functioning properly.

D.4.2.2 Group and Equipment Level Checks

Check of operability of the equipment will be accomplished by reviewing the status lamp indicators on the Remote Control/ Status monitor panel. The following lamp checks will be made:

INDICATOR	MODE
STATUS ON	ON
CONTROL REM	ON
CONTROL LOC	OFF
STATUS OFF	OFF
MALF EXEC	OFF
MALF MAINT	OFF
MALF DL	OFF

D.4.2.3 Suggested Troubleshooting Procedures

The person assigned to perform the maintenance during the test will not be given strict procedures for troubleshooting the equipment. Instead, he will be familiarized with the MLS technical manuals prior to testing and during testing he will use these manuals, as needed, to isolate failures and effect the appropriate corrective actions.

D.4.3 Task Selection and Simulation

D.4.3.1 Selection of Tasks

The selection of tasks for the initial sample size of 200 simulations is based on the maintainability analysis referenced in paragraph D.2.3. For this analysis, units are grouped by similar function or nature (e.g., antenna, transmitter, timing, etc.) in accordance with the task selection procedure of Appendix A, MIL-STD-471.

As information regarding the selection and nature of the malfunctions must be concealed from the personnel performing the simulations, the detailed methods of selection and installation of malfunctions are described in Supplement 1 to this Maintainability Demonstration Plan. This Supplement is the Procedure for Fault Installation.

Supplement 1 itemizes the 200 tasks and describes the random methods of selecting the tasks and type of representative malfunctions.

D.4.3.2 Simulation of Failures

Supplement 1 gives the specific methods for simulating and installing failures. The methods to be used will be non-destructive to the equipment. Where several failures are required on the same type of equipment, several different failure modes have been specified. Selection of these modes will be on a random basis.

The procedure which will be followed for installing a malfunction is given below.

The personnel who will perform the maintenance task will be sent from the area. The personnel installing the malfunction will select the task per Attachment 1, and check out the equipment per paragraph D.4.2. The unit will be removed from the rack, if necessary, and the malfunction will be installed. The unit will be closed up, returned to its position and checked to determine that the malfunction is operating as predicted. The Group and Equipment Level checks will then be made to determine that no other fault exists. The required test equipment will then be removed from the circuitry and the equipment will be set in a condition which simulates the flight line checkout conditions.

D.4.3.3 Demonstration of Maintenance Tasks

The level of maintenance to be demonstrated is the repair of the MLS Ground Subsystem at the organizational level by LRU replacement. Demonstration of maintenance tasks will be timed, and will include the time for verifying a failure condition, patching in any necessary test equipment; checking out and localizing the fault to the appropriate LRU; removing and replacing the LRU; adjusting, closing, and final rechecking of the site equipment to be sure that the malfunction has been corrected. For this level of maintenance, failures simulated in case-mounted parts will be repaired by treating the case as a replaceable module.

After the malfunction has been installed, the maintenance personnel will be returned to the area for the start of the timed demonstration.

The appropriate check out procedures as outlined in paragraph D.4.2.3 will be used to localize to the faulty unit. Required auxiliary test equipment and built-in test equipment will be in the area and warmed up if required but will not be patched into the test set-up. In order to assist the maintenance personnel, available handbooks and/or troubleshooting aids (e.g., module identification charts, schematics, test point diagrams, etc.) will be provided.

Repairs will be made by unit, board or module replacement, with faulty items replaced with working spares. Where spares are unavailable, timing of the demonstration will be stopped after removal of the correct item. The test director will have the fault removed and demonstration time will then resume. The LRU will be replaced and the equipment will be adjusted, closed up and checked out. At this time, the demonstration task is completed and the elapsed time and manpower required will be recorded in the appropriate logs.

D.5 REQUIRED SUPPORT EQUIPMENT

The following equipment will be required to operate and support the Maintainability Demonstration. All test equipment will be subject to standard calibration requirements. In addition to the listed equipment, associated cabling and connectors are required.

Stop Watch (2 required)	(To read 60 seconds with one sweep, and record a minimum of 30 minutes.) Gallet timer or equivalent
Variable Attenuator, RF	HPG382A
Power Meter, RF	HP435A

Power Sensor, RF	HP8481A
Oscilloscope	Tektronix 545B
Dual Trace Amplifier	Tektronix 1A2
Detector, RF	HP420
Power Divider	4042652-0701
A-C Clamp Volt-Ammeter	Weston 749
Coax to Waveguide Adaptors (4)	HPG281A
Signal Generator	HP618B
Variable Attenuator, RF	ARRA5804-20W
Phase Shifter	HPJ885A
Dummy Load	Narda 376NM
Test Probes	Tektronix P6006
Assorted Test Cables	RG214 and RG223

D.6 FAILURE PROCEDURES

If a real failure occurs, the failed module will be removed and replaced with a working spare. A defect tag will be completed for the failed unit, and it will be subject to the Bendix In-House Failure Analysis and Reporting procedure established for the MLS program. If a spare module is unavailable, the faulty one will be repaired for reuse in the test.

If the failure occurs while a task is in the process of demonstration, the demonstration will be aborted and appropriately logged. The demonstration personnel will leave the area while the radio set is being repaired. After the repair, the personnel will return and continue the task demonstration. Time recording for the task will again begin at this point.

D.7 TEST RECORDS

D.7.1 General Test Log

The General Test Log shown in Figure D.7-1 will provide a complete chronological record of all test activities and/or other actions performed on the equipment during the test period. It will contain a continuing history of equipment operation,

MLS MTTR DEMONSTRATION TEST
GENERAL TEST LOG

ENTRY NO.	DATE	TIME	REMARKS (ACTIVITY, DEVIATIONS, INTERRUPTIONS, REPLACEMENTS, ETC.	INITIALS

FIGURE D.7-1

malfunctions, repairs, removals, etc. If the entry pertains to the performance of a demonstration task, appropriate columns have been provided to identify the task and record that the malfunction was properly installed.

D.7.2 MTTR Test Scoring Chart

Figure D.7-2 shows the chart on which the maintenance downtime per corrective maintenance task (x_c) for each task will be recorded. There are columns on the chart to measure the following task time segments: fault location, including diagnostic and module isolation activities such as opening unit cases to gain access to test points; module removal and replacement; and final checkout and reassembly. Final checkout and reassembly times include adjustment and calibration time; all of these are collectively incorporated in one column since checks may be made before and after the unit is closed up.

D.7.3 Test Equipment and Facility Logs

The log of Figure D.7-3a will be used to record the types of equipment or facilities used in the test set-ups. When an equipment is removed for replacement, the appropriate data will also be recorded. Calibration and Renewal Data will be recorded in the log shown in Figure D.7-3b by personnel performing the procedure.

MLS MTTR DEMONSTRATION TEST

SCORING CHART

TASK NO.	LOCALIZE TIME (MIN.)	REMOVE AND REPLACE TIME (MIN.)	FINAL UNIT CHECKOUT TIME (MIN.)	TOTAL RESTORATION TIME

FIGURE D.7-2

SHEET ____ OF ____

MLS MAINTAINABILITY TEST

TEST EQUIPMENT AND FACILITY LOG

NOTES: 1. ENTER MODEL, SERIAL NUMBER, AND DATE WHEN EQUIPMENTS OR FACILITIES ARE PUT INTO USE.
2. WHEN EQUIPMENTS OR FACILITIES ARE REPLACED, ENTER THE NEW MODEL, SERIAL NUMBERS, AND THE DATE IN ADJACENT COLUMN.
3. REFERENCE THE LINE AND COLUMN ON THE GENERAL TEST LOG.

TEST STARTING DATE: ____________ TEST FINISHING DATE: ____________

LINE NO.	EQUIPMENT OR FACILITY	1	2	3	4	5	6

FIGURE D.7-3a

SHEET ____ OF ____

TEST EQUIPMENT AND FACILITY

CALIBRATION OR RENEWAL LOG

MLS MAINTAINABILITY TEST

NOTES: 1. CALIBRATION OR RENEWAL PERSONNEL WILL ENTER DATE AND INITIALS UPON SATISFACTORY COMPLETION OF APPROPRIATE PROCEDURE.
2. COMPLETE COLUMN 1 BEFORE STARTING COLUMN 2.

TESTING START DATE: ______________ TESTING FINISH DATE: ______________

LINE NO.	1	2	3	4	5

FIGURE D.7-3b

MAINTAINABILITY

DEMONSTRATION PLAN

SUPPLEMENT 1

FAULT INSTALLATION
PROCEDURE
FOR
MLS
GROUND SUBSYSTEM

Contract No.
DOT FA72WA-2801

Prepared by

The Bendix Corporation
Communication Division
Towson, Maryland 21204

November 1977

FAULT INSTALLATION PROCEDURE

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1.0 SCOPE

This document describes the procedure that will be used for the random selection of tasks to be demonstrated during the Maintainability test of the MLS Ground Subsystem. It further describes the methods for selecting specific malfunctions for each task. In addition, this attachment provides the procedures which will be used by the personnel installing the malfunctions to simulate faults in the equipment.

To maintain test integrity, the information contained in this document will be restricted and inaccessible to the personnel performing the task demonstrations.

2.0 REFERENCED DOCUMENTS

The following documents, of the issue in effect on the date of the contract, form a part of this procedure to the extent specified herein.

	Maintainability Demonstration Plan for MLS Ground Subsystems
	Reliability and Maintainability Predictions for Basic (Narrow) and Small Community Ground Subsystems
MIL-STD-471A	Maintainability Demonstration
	Tables for Statisticians, Herbert Arkin and Raymond Colton, Barnes & Noble, 1963

3.0 SELECTION OF TASKS

A demonstration population of 200 corrective maintenance tasks for the MLS ground subsystem has been prepared in accordance with the Task Sampling Method given in Appendix A of MIL-STD-471A.

Table 1 gives the distribution of these tasks among the various replacement items. In constructing the table, the individual replaceable items were grouped by the major units (antenna, transmitter, timing, etc.) which comprise the equipment

Table 1. Corrective Maintenance Task Stratification

(1) MAJOR UNITS	(2) FUNCTIONAL LEVEL OF MAINTENANCE	(3) MAINT TASK	(4) EST. MAINT TIME (MIN.)	(5) FAILURE RATE F/10^6 HRS	(6) QTY AZ & EL	(7) TASK GROUPING	(8) TOTAL FAILURE RATE	(9) RELATIVE FREQ	(10) DEMON POPULATION ALLOCATION	(11) DEMON SAMPLE SIZE
TWT AMP	TWT AMP	R/R (A)	19	61.333	2	GRP. 1, TASK A	122.666	0.142	28	7
RF UNIT	EXCITER	R/R (A)	19	11.894	2	GRP. 2, TASK S	68.662	0.079	A-6	4
	DPSK	R/R (B)	19	2.965	2	A, B, C, D			B-1 16	
	AMPLIT. MODULATOR	R/R (C)	19	19.110	2				C-9	
	DETECTOR AMP.	R/R (D)	19	0.362	2				D-8	
	CHASSIS PARTS	RP (E)	70	0.690	2	GRP. 3, TASK E	1.380	0.002	0	0
LOCAL CONTROL/STATUS	SYSTEM SYNC	R/R (A)	19	1.930*	2	GRP. 4	81.979	0.095	A-1	5
	DATA LINK	R/R (B)	19	3.300	2	TASK, A—P			B-2	
	AUX DATA LINK	R/R (C)	19	3.137	1				C-1	
	VARIABLE AUX DATA	R/R (D)	19	3.174	1				D-1	
	FIXED AUX 2	R/R (E)	19	4.115	1				E-1	
	FIXED AUX 1	R/R (F)	19	4.115	1				F-1	
	AUX/DS/WV	R/R (G)	19	2.355	1				G-1 19	
	AUX/AD/PAR	R/R (H)	19	2.905	1				H-1	
	MORSE CODE	R/R (I)	19	2.520	1				I-1	
	ID/BD/DPSK	R/R (J)	19	2.886	2				J-1	
	SYS TIME GEN	R/R (K)	19	3.889*	2				K-2	
	TIME CONTROL	R/R (L)	19	8.339*	2				L-3	
	10 MHz DRIVER	R/R (M)	19	0.088	2				M-3	
	10 MHz OSC	R/R (N)	19	3.393	2				N-1	
	SEP/TIMER	R/R (O)	19	3.213	2				O-1	
	LT DRIAL	R/R (P)	19	2.791	2				P-1	
	LC/ST. IND	R/R LED (Q)	30	2.000	2	GRP. 5, TASK Q	4.000	0.005	1	0
	RTM	R/R (R)	30	13.000	2	GRP. 6, TASK R	26.000	0.030	6	1
	CHASSIS PARTS	RP (S)	70	5.532*	2	GRP. 7, TASK S	11.064	0.013	3	1
POWER SUPPLY DRWR	20 V PWR SUPPLY	R/R (A)	10	0.754	2	GRP. 8	5.742	0.007	1	0
	15 V PWR SUPPLY	R/R (B)	10	1.440	2	TASKS A, B, C				
	5 V PWR SUPPLY	R/R (C)	10	0.677	2					
	CHASSIS PARTS	RP (D)	70	2.006*	2	GRP. 9, TASK D	4.012	0.005	1	0

Table 1. Corrective Maintenance Task Stratification (Cont)

(1) MAJOR UNITS	(2) FUNCTIONAL LEVEL OF MAINTENANCE	(3) MAINT TASK	(4) EST. MAINT TIME (MIN.)	(5) FAILURE RATE F/10^6 HRS	(6) QTY AZ & EL	(7) TASK GROUPING	(8) TOTAL FAILURE RATE	(9) RELATIVE FREQ	(10) DEMON POPULATION ALLOCATION	(11) DEMON SAMPLE SIZE
MAINT MONITOR DRWR	EXECUTIVE INTEG	R/R (A)	19	4.242	8	GRP. 10	209.620	0.242	A-7	
	MON. CNTRL	R/R (B)	19	1.671	2	TASKS A— T			B-1	
	MORSE CODE	R/R (C)	19	2.845	1				C-1	
	DPSK DECODE	R/R (D)	19	1.834	2				D-1	
	DPSK DECIDE	R/R (E)	19	4.254	2				E-2	
	DISC. DATA	R/R (F)	19	1.373	2				F-0	
	AN COMP. #3	R/R (G)	19	3.671	2				G-2	
	AN COMP. #2	R/R (H)	19	3.479	2				H-2	
	AU/AD/PAR	R/R (I)	19	2.933	1				I-1	
	ID/BD/DPSK	R/R (J)	19	2886	2				J-1	
	SYS TIME GEN	R/R (K)	19	4.341	2				K-2 } 48	12
	MON. TIME	R/R (L)	19	3.334	2				L-2	
	SCAN TIME	R/R (M)	19	17.731	2				M-8	
	AN COMP. #1	R/R (N)	19	3.546	2				N-2	
	DET/COMP	R/R (O)	19	1.420	2				O-1	
	BEAM ACCUR.	R/R (P)	19	6.238*	2				P-3	
	DIG. COMP.	R/R (Q)	19	11.556	2				Q-5	
	FREQ. MON.	R/R (R)	19	5.320	2				R-2	
	TIMING REFERENCE	R/R (S)	19	1.264	1				S-0	
	MAINT INTEG.	R/R (T)	19	3.889	6				T-5	
	MAINT MON. INDIC.	R/R LED (U)	30	8.400	2	GRP. 11, TASK U	16.800	0.019	4	1
	CHASSIS PARTS	RP (V)	70	3.268*	2	GRP. 12, TASK V	6.536	0.007	1	0
MON. PWR SUPPLY DRWR	MONITOR RCVR	R/R (A)	10	40.611	2	GRP. 13, TASKS	86.782	0.100	A-18	
	5 V PWR SUPPLY	R/R (B)	10	0.671	4	A, B, C			B-1 } 20	5
	15 V PWR SUPPLY	R/R (C)	10	1.438	2				C-1	
	CHASSIS PARTS	RP (D)	70	5.680*	2	GRP. 14, TASK D	11.360	0.013	3	1
COOLING FAN DRWR	CHASSIS PARTS	RP (A)	70	6.005	2	GRP. 15, TASK A	12.010	0.014	3	1

Table 1. Corrective Maintenance Task Stratification (Cont)

(1) MAJOR UNITS	(2) FUNCTIONAL LEVEL OF MAINTENANCE	(3) MAINT TASK	(4) EST. MAINT TIME (MIN.)	(5) FAILURE RATE F/10^6 HRS	(6) QTY AZ & EL	(7) TASK GROUPING	(8) TOTAL FAILURE RATE	(9) RELATIVE FREQ	(10) DEMON POPULATION ALLOCATION	(11) DEMON SAMPLE SIZE
ANTENNA	SCAN SWITCH	R/R (A)	20	2.381	20	GRP. 16, TASKS A, B, C	67.576	0.078	A-11	
	SCAN MODULATOR	R/R (B)	20	8.841	2				B-4 } 16	4
	ANT. SEL. SW.	R/R (C)	19	1.137*	2				C-1	
BEAM STEERING	SCAN CNTRL	R/R (A)	20	4.569	2	GRP. 18 TASKS A— I	51.680	0.060	A-2	
	SCAN CNTR COMP	R/R (B)	20	2.621	2				B-1	
	SCAN CNTR MON	R/R (C)	20	4.520	2				C-2	
	SCAN SW DRIVE	R/R (D)	20	2.422	1				D-1 } 12	3
	S.S. DRIVE INT.	R/R (E)	20	3.672	1				E-1	
	S.S. MONITOR	R/R (F)	20	4.087	2				F-2	
	S.S. MON. EXP.	R/R (G)	20	2.920	2				G-1	
	S.S. MON. INT.	R/R (H)	20	2.870	1				H-1	
	10 MHz OSC.	R/R (I)	20	2.641	2				I-1	
	CHASSIS PARTS	RP (J)	68	5.436*	2	GRP. 18, TASK J	10.872	0.013	3	1
ANT. PWR SUPPLIES	5 V PWR SUPPLY	R/R (A)	10	0.679	2	GRP. 19, TASKS A, B, C	4.052	0.005	1	0
	24 V PWR SUPPLY	R/R (B)	10	0.627	2					
	40 V PWR SUPPLY	R/R (C)	10	0.720	2					
	CHASSIS PARTS	RP (D)	68	0.082	2	GRP. 20, TASK D	0.164	0.000	0	0
MONITOR HORN ASSY	RF DETECTOR	R/R (A)	30	1.101	2	GRP. 21, TASKS A — E	7.906	0.009	A-1	
	BAND FILTER	R/R (B)	30	0.629	2				B-0	
	PWR DIVIDER	R/R (C)	30	0.943	2				C-1 } 2	1
	VIDEO AMP	R/R (D)	30	0.362	2				D-0	
	LPB NO. 3	R/R (E)	30	0.918	2				E-0	
	PWR DIST.	RP (F)	68	0.270	2	GRP. 22, TASK F	0.540	0.001	0	0
MISCELLANEOUS	ANT. MON. VIDEO AMPS	R/R (A)	30	0.241*	5	GRP. 21, TASKS A — E	40.103	0.046	A-0	
	LPB NO. 1	R/R (B)	30	1.994*	7				B-3	
	LPB NO. 2	R/R (C)	30	1.306*	4				C-7 } 9	2
	LPB NO. 4	R/R (D)	30	4.583*	2				D-2	
	LPB NO. 5	R/R (E)	30	5.275*	2				E-3	
	PWR DISTRIB.	RP (F)	70	6.685	2	GRP. 24, TASK F	13.370	0.015	3	1
							864.876	1.000	200	50

level for which the demonstration is being conducted. Failure rates for each of the boards/modules were derived from the reliability prediction. Column 9 of Table 1 gives the relative frequency of occurrence of each of the maintenance tasks (or a percentage of the item failure rate to the total failure rate). These relative frequencies are then used to allocate the population of 200 tasks (column 10) among each of the maintenance tasks identified in columns 3 and 7. Column 11 presents the demonstration sample size of 50 tasks, from the population of 200 tasks, which have been allocated to each task group by relative frequency.

4.0 SELECTION OF MALFUNCTIONS

4.1 General Philosophy

The methods which will be used to simulate malfunctions were selected on the general basis of causing no electrical or mechanical damage or degradation to the equipment with respect to workmanship, overstress, or disruption of critical alignments or adjustments.

Applicable methods will include disconnecting leads from terminal pins and/or internal circuit elements, installing jumper wires, using faulty parts in place of good ones, adding certain parts to simulate faults, and misadjusting non-critical internal controls.

Disconnecting leads or attaching jumpers will be done internal to the LRU, where practical. For those tasks where internal simulation of a malfunction is impractical, the malfunction will be installed externally in a manner which will minimize the possibility of visual clues, e.g., from the back of the rack, or in the inter-connecting cabling. This procedure will correctly simulate a malfunction which would be internal to the box through isolation to the faulty unit, removal and replacement, up to rechecking the unit. At this time, the malfunction would be corrected if it were internal and the succeeding checkout would be favorable. To simulate this

condition, the following procedure will be adopted. The task will be conducted normally up to the point where the faulty unit has been isolated and removed. Time recording will then stop and the external fault will be repaired. Time recording will then resume for the replacement and checkout portions of the task. This procedure will accurately simulate the time required to perform the maintenance task.

4.2 Malfunction Installation Guide

Table 2 lists the specific malfunctions which will be installed in the various boards/modules. The table gives the symptom to be simulated, a description of the simulated failure and the method for simulating the symptom.

Where more than one task is to be demonstrated on a given board, several modes of failure are given to provide a variety of malfunctions. In selecting the various symptoms, consideration was given to typical modes of failure and comparative complexity of various functions within the module.

5.0 APPLICABILITY OF TASK DATA

The last column of Table 2 shows identifying task numbers for the two hundred malfunctions. To randomly select the task sequence for the 50 tasks to be demonstrated, chits will be prepared, one for each of the 200 task numbers. At the time of the demonstration, the chits will be placed in a container and mixed. At the start of each task demonstration, a chit will be drawn from the container, lottery fashion, and that task will be demonstrated.

As the test proceeds, a tally will be maintained of the demonstration sample, so that the number of tasks demonstrated for each individual maintenance task identified in column 3 of Table 1 does not exceed the sample size allocated to that task, as given in column 11 of the same table (as noted in paragraph

A.10.4.J of MIL-STD-471A). With this method of selection, the sequence in which the tasks are demonstrated is selected randomly while the appropriate weighting by frequency of occurrence is preserved.

TABLE 2. MALFUNCTION INSTALLATION GUIDE

MAJOR UNIT	MAINTENANCE LEVEL	SYMPTOM NO.	SYMPTOM	METHOD OF INSTALLATION	CONDITIONS OR NOTES	IDENT. NO.
TWT AMP	TWT AMP	1	NO LIGHTS ILLUMINATED ON TWT. SYSTEM SHUTDOWN. ERP AND/OR TWT MONITOR LIGHTS LIGHT (ON MONITOR PANEL).	BLOWN FUSE	BAD FUSE	1
		2	SYSTEM SHUTDOWN. ERP AND/OR TWT MONITOR LIGHTS LIGHT ON MONITOR PANEL	DISCONNECT COAX FROM TWT INPUT. (INSIDE TWTA)	SIMULATE BAD TWT INPUT CABLE OR BAD TWT INPUT CONNECTOR	2
		3	SYSTEM SHUTDOWN. ERP AND TWT MONITOR LIGHTS LIGHT ON MONITOR PANEL. TWT OVER TEMPERATURE FAULT LIGHT LIGHTS. TWT WON'T RESET.	SHORT THERMO-STAT ON TWT HEAT SINK.	SIMULATE TWT OVER-TEMPERATURE	3
		4	SYSTEM SHUTDOWN. ERP AND/OR TWT MONIOR LIGHTS ON MONITOR PANEL LIGHT. NO INDICATORS ILLUMINATED ON TWT.	DISCONNECT WIRE ON TWT AC POWER SWITCH	SIMULATE BAD AC PWR SWITCH	4
		5	SYSTEM SHUTDOWN. TWT WILL NOT GO INTO "OPERATE" MODE (HV WILL NOT TURN ON).	SHORT A2U1-10 TO GND	SIMULATE BAD A2U1	5
		6	SYSTEM SHUTDOWN. TWT WILL NOT GO INTO "OPERATE" MODE.	SHORT A3U2-7 TO GND	SIMULATE BAD A2U2	6
		7	SYSTEM SHUTDOWN. TWT "HELIX OVER-LOAD" LIGHT ILLUMINATED. TWT WILL NOT GO INTO OPERATE MODE.	SHORT A2U3-11 TO GND	SIMULATE BAD A2U3	7
		8	SYSTEM SHUTDOWN. TWT HAS NORMAL INDICATIONS. (ERP AND/OR TWT LIGHTS ON MONITOR LIT.)	SHORT A2TP2 TO GND	SIMULATE BAD Q9	8
		9	SYSTEM SHUTDOWN. NO TWT INDICATORS LIT EXCEPT FOR AC POWER.	DISCONNECT JUMPER BETWEEN E1 AND E2	SIMULATE BAD T1	9
		10	SYSTEM SHUTDOWN. NO TWT INDICATORS LIT. (TWT AND/OR ERP LIGHTS LIT ON MONITOR PANEL.)	DISCONNECT WIRE FROM INTERLOCK SWITCH S4	SIMULATE BAD INTERLOCK SWITCH	10

TABLE 2. MALFUNCTION INSTALLATION GUIDE

MAJOR UNIT	MAINTENANCE LEVEL	SYMPTOM NO.	SYMPTOM	METHOD OF INSTALLATION	CONDITIONS OR NOTES	IDENT. NO.
TWT AMP (CONT'D)	TWT AMP	11	SYSTEM SHUTDOWN. TWT INDICATORS OFF EXCEPT "AC POWER"	DISCONNECT WIRE FROM + TERMINAL OF RECTIFIER (QUAD) CR1.	SIMULATE BAD RECTIFIER (CR1)	11
		12	SYSTEM SHUTDOWN. TWT INDICATORS OFF EXCEPT AC POWER.	DISCONNECT WIRE BETWEEN E5 AND E6.	SIMULATE BAD Q1	12
		13	SYSTEM SHUTDOWN. TWT INDICATORS NORMAL. (MONITOR TWT AND ERP LIGHTS ON.)	DISCONNECT J6 FROM A3.	SIMULATE BAD A3T1	13
		14	SYSTEM SHUTDOWN. TWT INDICATORS OFF EXCEPT AC POWER.	DISCONNECT J5 FROM A3.	SIMULATE BAD A3T2	14
		15	SYSTEM SHUTDOWN. TWT INDICATORS OFF.	DISCONNECT CABINET CABLE FROM J3 OF TWT.	SIMULATE BAD J3	15
		16	SYSTEM SHUTDOWN. TWT HELIX FAULT LIGHT LIT.	SHORT JUNCTION OF A2R48 AND A2CR9 TO GROUND.	SIMULATE BAD A2Q10	16
		17	SYSTEM WILL NOT TRANSMIT, WILL NOT TURN ON WHEN "RESET"SWITCH ACTIVATED ON LOCAL CONTROL/STATUS PANEL. TWT "READY" AND "OPERATE" LIGHTS OFF.	SHORT A2C17 + TO GROUND.	SIMULATE BAD A2C17	17
		18	SYSTEM WILL NOT TRANSMIT, WILL NOT TURN ON WHEN "RESET" SWITCH ACTIVATED ON LOCAL CONTROL/STATUS PANEL TWT "READY" AND "OPERATE" LIGHTS OFF.	CONNECT JUMPER ACROSS A2R45.	SIMULATE BAD Q8	18
		19	SYSTEM SHUTDOWN. TWT HELIX FAULT LIGHT LIT.	SHORT A2U7-5 TO GROUND.	SIMULATE BAD U7	19

TABLE 2. MALFUNCTION INSTALLATION GUIDE

MAJOR UNIT	MAINTENANCE LEVEL	SYMPTOM NO.	SYMPTOM	METHOD OF INSTALLATION	CONDITIONS OR NOTES	IDENT. NO.
TWT AMP (CONT'D)	TWT AMP	20	SYSTEM SHUTDOWN. TWT INDICATORS NORMAL. SYSTEM WON'T RESTART.	DISCONNECT WIRE FROM LINE FILTER FL5	SIMULATE BAD LINE FILTER	20
		21	SYSTEM SHUTDOWN. TWT IN "READY" MODE, WON'T GO TO "OPERATE".	DISCONNECT WIRE FROM LINE FILTER FL4	SIMULATE OPEN CONTACTS	21
		22	SYSTEM SHUTDOWN. TWT IN "READY" MODE, SYSTEM WON'T RESTART.	PLACE STANDBY, OPERATE SWITCH IN STANDBY POSITION	SIMULATE BAD SWITCH	22
		23	SYSTEM SHUTDOWN. ONLY TWT AC PWR LIGHT ON.	DISCONNECT R4 AND RT2 FROM COMMON TERMINAL	SIMULATE OPEN WIRE OR BAD R4 AND RT2	23
		24	SYSTEM SHUTDOWN. ONLY TWT AC PWR LIGHT ON.	DISCONNECT JUMPER BETWEEN E3 AND E4	SIMULATE OPEN PRIMARY WINDING ON T1	24
		25	SYSTEM SHUTDOWN. NO TWT INDICATORS ON.	DISCONNECT WIRE FROM FL2	SIMULATE OPEN AC LINE FILTER	25
		26	SYSTEM SHUTDOWN. TWT IN "READY" MODE. WON'T GO TO "OPERATE".	DISCONNECT WIRE FROM LINE FILTER FL4	SIMULATE BAD LINE FILTER FL4	26
		27	SYSTEM SHUTDOWN. TWT IN "READY" MODE. WON'T GO TO OPERATE.	DISCONNECT WIRE FROM LINE FILTER FL4	SIMULATE BAD A2U1.	27
		28	SYSTEM SHUTDOWN. NO TWT INDICATORS ON.	DISCONNECT WIRE FROM LINE FILTER FL3	SIMULATE OPEN CONTACT ON J3-N	28

TABLE 2. MALFUNCTION INSTALLATION GUIDE

MAJOR UNIT	MAINTENANCE LEVEL	SYMPTOM NO.	SYMPTOM	METHOD OF INSTALLATION	CONDITIONS OR NOTES	IDENT. NO.
RF UNIT	EXCITER	1	SYSTEM SHUTDOWN. "FREQ" LIGHT ON MONITOR PANEL ON.	ADJ EXCITER "FREQ ADJ" UNTIL FREQ IS OFF NOMINAL GREATER THAN 12 kHz	SIMULATE FREQUENCY ERROR	29
		2	SYSTEM SHUTDOWN. "FREQ" LIGHT ON ON MONITOR PANEL.	DISCONNECT CABLE FROM "XTAL FREQ" CONNECTOR OF EXCITER	SIMULATE NO XTAL FREQ OUTPUT FROM EXCITER	30
		3	SYSTEM SHUTDOWN.	DISCONNECT A2P1 FROM EXCITER POWER CONNECTOR	SIMULATE EXCITER FAILURE	31
		4	SYSTEM SHUTDOWN.	DISCONNECT CABLE FROM RF OUTPUT CONNECTOR ON EXCITER	SIMULATE EXCITER MULTIPLIER OR VCO FAILURE	32
		5	SYSTEM SHUTDOWN	REMOVE CRYSTAL FROM EXCITER	SIMULATE BAD CRYSTAL	33
		6	SYSTEM SHUTDOWN. "FREQ" LIGHT ON ON MONITOR PANEL.	DISCONNECT WIRE FROM E1 ON SAME P.C. BOARD AS CRYSTAL (IN EXCITER)	SIMULATE OPEN CONTROL FAILURE	34
	BIPHASE MODULATOR (DPSK)	1	SYSTEM SHUTDOWN	SHORT E1 OR E2 ON STRIP-LINE ASSY	SIMULATE SHORTED DIODE	35

TABLE 2. MALFUNCTION INSTALLATION GUIDE

MAJOR UNIT	MAINTENANCE LEVEL	SYMPTOM NO.	SYMPTOM	METHOD OF INSTALLATION	CONDITIONS OR NOTES	IDENT. NO.
RF UNIT (CONT'D)	AMPLITUDE MODULATOR	1	AMPLITUDE MODULATOR FAULT (MAY RESULT IN TEST PULSE ACCURACY FAULT AND EXECUTIVE SHUTDOWN).	SHORT Q1 COLLECTOR (CASE) TO GROUND (CHASSIS)	SIMULATE SHORTED Q1	36
		2	AMPLITUDE MODULATOR FAULT.	SHORT U2-11 TO GROUND	SIMULATE BAD U2	37
		3	AMPLITUDE MODULATOR FAULT.	SHORT Q2 COLLECTOR (CASE) TO GROUND	SIMULATE BAD Q2	38
		4	AMPLITUDE MODULATOR FAULT.	SHORT U3-1 TO GROUND	SIMULATE BAD U3	39
		5	AMPLITUDE MODULATOR FAULT.	SHORT U1-1 TO GROUND	SIMULATE BAD U1	40
		6	AMPLITUDE MODULATOR FAULT.	SHORT U7-9 TO GROUND	SIMULATE BAD U7	41
		7	AMPLITUDE MODULATOR FAULT.	SHORT U6-11 TO GROUND	SIMULATE BAD U6	42
		8	AMPLITUDE MODULATOR FAULT.	SHORT U11-5 TO GROUND	SIMULATE BAD U11	43
		9	AMPLITUDE MODULATOR FAULT.	UNSCREW CR1 OF STRIPLINE ≈3 TURNS	SIMULATE OPEN DIODE	44

TABLE 2. MALFUNCTION INSTALLATION GUIDE

MAJOR UNIT	MAINTENANCE LEVEL	SYMPTOM NO.	SYMPTOM	METHOD OF INSTALLATION	CONDITIONS OR NOTES	IDENT. NO.
LOCAL CONTROL/ STATUS ASS'Y	SYSTEM SYNC	1	TIMING SYNC LAMP WILL COME ON, ON THE EL MAINTENANCE MONITOR ELEVATION SITE WILL GO DOWN.	TURN THE AZIMUTH SITE OFF OR PUT THE AZIMUTH SITE IN "TEST MODE" OR REMOVE THE BBF (A3) BOARD FROM THE AZIMUTH LC/S DRAWER.	BEFORE THE EL CAN BE REINSTATED THE ERROR MUST BE CORRECTED AT AZ.	45
	DATA LINK	1	DATA LINK LAMP ON THE MAINTENANCE MONITOR PANEL WILL SHOW DATA LINK ERROR. SYSTEM WILL REMAIN UP. ALSO REMOTE CONTROL/STATUS PANEL WILL NOT SHOW PROPER INDICATIONS FOR THE AZIMUTH STATUS; ELEVATION STATUS.	ON THE BBD BOARD (A4) SHORT TP5 TO GND: AZ LC/S-EL LC/S.	CONDITIONS LISTED FOR BOTH AZIMUTH & ELEVATION.	46
		2	DATA LINK ERROR LIGHT WILL APPEAR ON THE REMOTE CONTROL/STATUS PANEL. NO UPDATE DATA WILL BE MADE.	ON THE BDC BOARD LOCATED IN SLOT A2 OF THE REMOTE CONTROL/STATUS ASS'Y. SHORT TP5 TO GROUND.	REMOTE CONTROL STATUS ONLY.	47
	AUX DATA LINK	1	SELECTION OF THE VAR. AUX DATA BY MEANS OF DRY, WET, ICY & CAT I, CAT II, CAT III, ---. WILL NOT BE AFFECTED WHEN THE SELECTOR SWITCHES ARE ADJUSTED.	ON THE BDC BOARD (A6) SHORT TP5 TO GND ON AZIMUTH LC/S.	AZIMUTH ONLY.	48
	VARIABLE AUX DATA	1	AUX DATA WORD IN ADDRESS 6 WILL NOT BE PRESENT. AUX DATA LAMP WILL COME ON, ON THE MAINTENANCE MONITOR.	ON THE BAG BOARD IN SLOT (A10) SHORT TEST POINTS TP1 TO GROUND.	AZIMUTH ONLY.	49

TABLE 2. MALFUNCTION INSTALLATION GUIDE

MAJOR UNIT	MAINTENANCE LEVEL	SYMPTOM NO.	SYMPTOM	METHOD OF INSTALLATION	CONDITIONS OR NOTES	IDENT. NO.
LOCAL CONTROL/ STATUS ASS'Y (CONT'D)	FIXED AUX DATA NO. 1 "BAR" BOARD	1	FIXED AUX DATA WORD IN ADDRESS 3 WILL BE MISSING AND ERROR LIGHT (AUX DATA) WILL DEVELOP ON THE MAINTENANCE MONITOR PANEL.	ON THE BAR BOARD IN SLOT (A12) SHORT PIN U12-9 TO GROUND.	AZIMUTH ONLY.	50
	FIXED AUX DATA 2. "BAS" BOARD	1	FIXED AUX DATA WORD IN ADDRESS 5 WILL BE MISSING FROM THE DATA STREAM. AUX DATA LAMP WILL COME ON ON THE MAINTENANCE MONITOR.	ON THE BAS BOARD IN SLOT A11 - PLACE A SHORT FROM U12-9 TO GROUND.	AZIMUTH ONLY.	51
	AUX DATA SELECTOR/WORD VERIFIER	1	FIXED AUX DATA WORD IN ADDRESS 4 WILL NOT BE TRANSMITTED AND FIXED AUX DATA IN ADDRESS 5 WILL NOT BE VERIFIED. AUX DATA LAMP ON THE MAINTENANCE MONITOR.	ON THE BAP BOARD IN SLOT A13 - PLACE A SHORT FROM U6-8 TO GROUND	AZIMUTH ONLY.	52
	AUX/ID/ ADDRESS/PARITY GENERATOR	1	THE AUX DATA WORDS WILL HAVE THE WRONG FUNCTION IDENTIFICATION CODE. THE MAINTENANCE MONITOR WILL DETECT THIS AND DECLARE A AUX DATA ERROR AND A PREAMBLE ERROR THEN SHUT THE SUBSYSTEM.	ON THE BAW BOARD LOCATED IN SLOT A14 - SHORT PIN U13-2 TO GROUND.	AZIMUTH ONLY	53
	MORSE CODE	1	SYSTEM WILL GO OFF THE AIR AND THE MAINTENANCE MONITOR WILL INDICATE A PREAMBLE ERROR.	ON THE BAM BOARD LOCATED IN SLOT A-16 - SHORT TO GROUND U13-12	AZIMUTH ONLY	54
	ID/BD/DPSK	1	NO DATA IS BEING TRANSMITTED. SYSTEM WILL GO OFF THE AIR. MAINTENANCE MONITOR WILL HAVE PREAMBLE, BASIC DATA, IDENT., AUX. LAMPS WILL BE ON.	ON THE BAM BOARD IN SLOT A16 SHORT TP8 TO GROUND.	AZ OR EL	55
	SYS TIMING GEN	1	ELEVATION WILL GO DOWN ON SYS TIMING ERROR	ON THE BAK BOARD SHORT OUT U22-1 TO GROUND	AZIMUTH ONLY	56

TABLE 2. MALFUNCTION INSTALLATION GUIDE

MAJOR UNIT	MAINTENANCE LEVEL	SYMPTOM NO.	SYMPTOM	METHOD OF INSTALLATION	CONDITIONS OR NOTES	IDENT. NO.
LOCAL CONTROL/ STATUS ASS'Y (CONT'D)	SYS TIMING GEN (CONT'D)	2	ELEVATION WILL GO DOWN ON SYS TIMING ERROR	ON THE BAX BOARD SHORT U20-13 TO GROUND	ELEVATION ONLY	57
	TIMING CONTROL	1	SYSTEM WILL GO OFF THE AIR WITH ERP ERRORS & POSSIBLY OTHER ERRORS AS THE SIGNALS TURNING THE TRANSMITTER ON ARE INHIBITED.	ON THE BAL BOARD SHORT U8-4 TO GROUND	AZIMUTH ONLY	58
		2	SYSTEM WILL GO OFF THE AIR WITH ERP ERRORS & POSSIBLY OTHER ERRORS AS THE SIGNALS TURNING THE TRANSMITTER ON HAVE BEEN INHIBITED	ON THE BAY BOARD SHORT U9-1 TO GROUND	ELEVATION ONLY	59
		3	ELEVATION WILL GO DOWN ON BEAM ACCURACY & BEAM ERP AS THE BEAM IS BEING CUT OFF ABOVE THE 2.5° OF THE MONITOR HORN.	NOTE THE SETTING OF SWITCH S5 & RECORD IT SO THAT THE SYSTEM MAY BE RESTORED TO ITS NORMAL OPERATING SETTING. AFTER THIS HAS BEEN DONE MOVE THE SWITCH FROM POSITION #3 TO POSITION #2.	ELEVATION ONLY	60
	10 MHz OSC.	1	SUBSYSTEM WILL GO DOWN WITH EXECUTIVE ERROR. ON MONITOR THIS ERROR COULD BE SEVERAL DIFFERENT ERRORS. DEPENDING ON WHERE IN TIME THAT THE PLUG P9 WAS REMOVED.	ON THE REAR OF THE LOCAL CONTROL/STATUS REMOVE P-9 FROM J9.	AZIMUTH AND ELEVATION	61

TABLE 2. MALFUNCTION INSTALLATION GUIDE

MAJOR UNIT	MAINTENANCE LEVEL	SYMPTOM NO.	SYMPTOM	METHOD OF INSTALLATION	CONDITIONS OR NOTES	IDENT. NO.
LOCAL CONTROL/ STATUS ASS'Y (CONT'D)	SEQUENCER/ TIMER	1	AZIMUTH AND ELEVATION WILL GO OFF THE AIR. AZIMUTH MONITOR WILL INDICATE A LOCAL CONTROL ERROR. THE ELEVATION WILL INDICATE A SYNC TIMING ERROR.	ON THE BBB BOARD IN SLOT A2 SHORT TP4 TO GROUND	AZIMUTH ONLY	62
	LIGHT/DRIVER	1	WHEN THE SUBSYSTEM GOES DOWN THE AURAL ALARM WILL NOT SOUND.	ON THE BBA BOARD IN SLOT A1, GROUND TP4. CREATE AN EXECUTIVE ERROR BY TURNING OFF THE LOCAL CONTROL ON/OFF SWITCH MOMENTARILY.	AZIMUTH OR ELEVATION	63
	LOCAL CONTROL STATUS INDICATOR	1	ALL THE STATUS INDICATOR LAMPS ON THE LOCAL CONTROL/STATUS PANEL WILL LIGHT UP.	ON THE BBA BOARD LOCATED IN SLOT A1 GROUND TP3	AZIMUTH OR ELEVATION	64

TABLE 2. MALFUNCTION INSTALLATION GUIDE

MAJOR UNIT	MAINTENANCE LEVEL	SYMPTOM NO.	SYMPTOM	METHOD OF INSTALLATION	CONDITIONS OR NOTES	IDENT. NO.
LOCAL CONTROL/ STATUS ASS'Y (CONT'D)	RUNNING TIME METER	1	RUNNING TIME METER IS NOT RUNNING.	ON TERMINAL BOARD TB-5 LOCATED IN THE BOTTOM REAR OF THE ELECTRONICS CABINET (DRAWER MUST BE REMOVED) AFTER TURNING THE AC OFF AT CIRCUIT BREAKER CB-22 REMOVE WIRE TB5-3. MOVE IT A SAFE DISTANCE FROM THE T.B. TURN CIRCUIT BREAKER CB22 BACK ON.	NOTICE CAUTION THIS INVOLVES 120V AC. SO THE AC SHOULD BE TURNED OFF AT THE CIRCUIT BREAKER AZ1A1CB2 BEFORE ANY ATTEMPT IS MADE TO IMPLEMENT THE FOLLOWING 4 PROBLEMS. AZIMUTH ONLY	65
		2	RUNNING TIME METER IS NOT RUNNING.	FOLLOW PROCEDURE IN #1. ONLY REMOVE TB5-10.	AZIMUTH ONLY	66
		3	RUNNING TIME METER NOT RUNNING.	FOLLOW PROCEDURE IN NO. 1.	ELEVATION ONLY	67
		4	RUNNING TIME METER NOT RUNNING.	FOLLOW PROCEDURE IN NO. 2.	ELEVATION ONLY	68
		5	RUNNING TIME METER NOT RUNNING.	REMOVE FUSE (F1) ON REAR OF LOCAL CONTROL/STATUS DRAWER.	AZIMUTH ONLY	69

TABLE 2. MALFUNCTION INSTALLATION GUIDE

MAJOR UNIT	MAINTENANCE LEVEL	SYMPTOM NO.	SYMPTOM	METHOD OF INSTALLATION	CONDITIONS OR NOTES	IDENT. NO.
LOCAL CONTROL/ STATUS ASS'Y (CONT'D)	RUNNING TIME METER (CONT'D)	6	RUNNING TIME METER NOT RUNNING	REMOVE FUSE (F1) ON REAR OF LOCAL CONTROL/STATUS	ELEVATION ONLY	70
	CHASSIS PARTS	1	NO SIGNALS PRESENT ON BNC JACKS ON FRONT PANEL. RUNNING TIME METER STOPS.	BEHIND FRONT PANEL OF AZIMUTH LOCAL CONTROL/STATUS DRAWER REMOVE PLUG P8 (RIGHT SIDE)	AZIMUTH ONLY	71
		2	NO SIGNALS PRESENT ON BNC JACKS ON FRONT PANEL. RUNNING TIME METER STOPS.	BEHIND FRONT PANEL OF ELEVATION LOCAL CONTROL REMOVE PLUG P8 (RIGHT SIDE)	ELEVATION ONLY	72
		3	MORSE CODE WILL NOT SHUT OFF.	ON SWITCH S6 AT THE REAR OF THE LOCAL CONTROL/STATUS PANEL PLACE A JUMPER WIRE BETWEEN TERMINALS 1 AND 3	AZIMUTH ONLY	73

TABLE 2. MALFUNCTION INSTALLATION GUIDE

MAJOR UNIT	MAINTENANCE LEVEL	SYMPTOM NO.	SYMPTOM	METHOD OF INSTALLATION	CONDITIONS OR NOTES	IDENT. NO.
POWER SUPPLY DRWR	20V POWER SUPPLY	1	SYSTEM SHUTDOWN. EXCITER AND TWT LIGHTS ON MONITOR PANEL ON.	REMOVE AC WIRE FROM 20V POWER SUPPLY TERMINAL BOARD	SIMULATES BAD POWER SUPPLY	74
	CHASSIS PARTS	1	SYSTEM SHUTDOWN.	REMOVE +20 VOLT POWER SUPPLY FUSE FROM FRONT PANEL	BAD FUSE	75

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MAJOR UNIT	MAINTENANCE LEVEL	SYMPTOM NO.	SYMPTOM	METHOD OF INSTALLATION	CONDITIONS OR NOTES	IDENT. NO.
MAINT. MONIT. DRWR.	EXECUTIVE INTEGRATOR 'BCD'	1	PRAMBL LIGHT ON. SYSTEM SHUTDOWN; EXEC. FAULT.	SHORT U26-8 TO GROUND AZ1A1A1A4A3		76
		2	SCAN MOD LIGHT ON. SYSTEM SHUTDOWN; EXEC. FAULT.	SHORT U30-8 TO GROUND AZ1A1A1A4A3		77
		3	LCL CONT LIGHT ON. SYSTEM SHUTDOWN; EXEC. FAULT.	SHORT U30-6 TO GROUND AZ1A1A1A4A4		78
		4	BEAM ERP LIGHT ON. SYSTEM SHUTDOWN; EXEC. FAULT.	SHORT U26-8 TO GROUND AZ1A1A1A4A19		79
		5	SLS LEFT LIGHT ON. SYSTEM SHUTDOWN; EXEC. FAULT.	SHORT U30-8 TO GROUND AZ1A1A1A4A19		80
		6	FREQ LIGHT ON. SYSTEM SHUTDOWN; EXEC. FAULT.	SHORT U26-8 TO GROUND AZ1A1A1A4A20		81
		7	BEAM ACCURACY LIGHT ON. SYSTEM SHUTDOWN; EXEC. FAULT.	SHORT U30-8 TO GROUND AZ1A1A1A4A20		82
	MONITOR CONTROL 'BCM'	1	EXEC FAULT: SYSTEM SHUTDOWN.	SHORT U11-4 TO GROUND AZ1A1A1A4A6		83
	MORSE CODE GENERATOR 'BAN'	1	PRAMBL LIGHT ON. EXEC. FAULT; SYSTEM SHUTDOWN.	SHORT U12-12 TO GROUND AZ1A1A1A4A7		84
	DPSK DECODER 'BCA'	1	PRAMBL LIGHT ON. EXEC. FAULT; SYSTEM SHUTDOWN.	SHORT TP4 TO GROUND AZ1A1A1A4A8		85

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MAJOR UNIT	MAINTENANCE LEVEL	SYMPTOM NO.	SYMPTOM	METHOD OF INSTALLATION	CONDITIONS OR NOTES	IDENT. NO.
MAINT. MONIT. DRWR. (CONT'D)	ANALOG COMPARATOR #3 'BCW'	1	ANTENNA +24V LIGHT ON. MAINT. FAULT.	SHORT U2-5 TO GROUND AZ1A1A1A4A11		86
		2	MONITOR +5V LIGHT ON. MAINT. FAULT.	SHORT U9-5 TO GROUND AZ1A1A1A4A11		87
	ANALOG COMPARATOR #2 'BCG'	1	TWTA PWR OUT LIGHT ON. MAINT. FAULT.	SHORT U6-13 TO GROUND AZ1A1A1A4A13		88
		2	EXCTR PWR OUT LIGHT ON. MAINT. FAULT.	SHORT U9-13 TO GROUND AZ1A1A1A4A13		89
	DPSK MONITOR DECISION 'BCB'	1	PRAMBL LIGHT ON. EXEC. FAULT; SYSTEM SHUTDOWN.	SHORT B20 TO GROUND AZ1A1A1A4A9		90
		2	AUX INP LIGHT ON. MAINT. FAULT.	SHORT B7 TO GROUND AZ1A1A1A4A9		91
	AUX ID/ ADDRESS/PARITY GENERATOR 'BAW'	1	PRAMBL LIGHT ON. EXEC. FAULT; SYSTEM SHUTDOWN.	SHORT TP-7 TO GROUND AZ1A1A1A4A24		92
	ID/BASIC DATA/ DPSK 'BAM'	1	PRAMBL LIGHT ON. EXEC. FAULT; SYSTEM SHUTDOWN.	SHORT TP-7 TO GROUND AZ1A1A1A4A25		93
	AZIMUTH SYSTEM TIMING GEN 'BAK'	1	PRAMBL LIGHT ON. EXEC. FAULT; SYSTEM SHUTDOWN.	SHORT U12-6 TO GROUND AZ1A1A1A4A26	DISABLES MORSE CODE GEN	94
		2	PRAMBL LIGHT ON. EXEC. FAULT; SYSTEM SHUTDOWN.	SHORT U10-8 TO GROUND AZ1A1A1A4A26	DISABLES DPSK GEN	95

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MAJOR UNIT	MAINTENANCE LEVEL	SYMPTOM NO.	SYMPTOM	METHOD OF INSTALLATION	CONDITIONS OR NOTES	IDENT. NO.
MAINT. MONIT. DRWR. (CONT'D)	MONITOR TIMING 'BCL'	1	MON TMG LIGHT ON. EXEC. FAULT; SYSTEM SHUTDOWN.	SHORT U10-5 TO GROUND A21A1A1A4A28	REMOVES SEQUENCE INPUT TO MONITOR CONTROL	96
		2	LEFT SLS LIGHT ON. EXEC. FAULT; SYSTEM SHUTDOWN.	SHORT U1-10 TO GROUND A21A1A1A4A28	REMOVES 100 kHz CLOCK	97
	SCAN TIMING 'BCJ'	1	BEAM ACCURACY LIGHT ON. EXEC. FAULT; SYSTEM SHUTDOWN.	SHORT TP8 TO GROUND A21A1A1A4A29	ALSO CAUSES MAIN. FAULT - TWTA PWR OUT	98
		2	TEST PULSE ACCURACY LIGHT ON. EXEC. FAULT; SYSTEM SHUTDOWN.	SHORT TP2 TO GROUND A21A1A1A4A29		99
		3	SLS LEFT LIGHT ON. EXEC. FAULT; SYSTEM SHUTDOWN.	SHORT U2-6 TO GROUND A21A1A1A4A29		100
		4	SLS RIGHT LIGHT ON. EXEC. FAULT; SYSTEM SHUTDOWN.	SHORT U3-6 TO GROUND A21A1A1A4A29		101
		5	IDENT ERP LIGHT ON. EXEC. FAULT; SYSTEM SHUTDOWN.	SHORT U22-6 TO GROUND A21A1A1A4A29		102
		6	TEST PULSE ACCURACY LIGHT ON. EXEC. FAULT; SYSTEM SHUTDOWN.	SHORT TP7 TO GROUND A21A1A1A4A29		103

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MAJOR UNIT	MAINTENANCE LEVEL	SYMPTOM NO.	SYMPTOM	METHOD OF INSTALLATION	CONDITIONS OR NOTES	IDENT. NO.
MAINT. MONIT. DRWR. (CONT'D)	SCAN TIMING 'BCJ' (CONT'D)	7	EXEC & MAINT FAULTS; SYSTEM SHUTDOWN. (SEE NOTES)	SHORT U6-1 TO GROUND A21A1A1A4A29	ELIMINATES START PULSE CAUSING MAINT FAULT: TWTA PWR OUT, AND 1 OF 6 POSSIBLE EXEC FAULT INDICATIONS 1) BEAM ACCURACY 2) TEST PULSE ACCURACY 3) BEAM ERP 4) SLS LEFT 5) SLS RIGHT 6) IDENT ERP	104
		8	EXEC & MAINT FAULTS; SYSTEM SHUTDOWN. (SEE NOTES)	SHORT U1-10 TO GROUND A21A1A1A4A29	ELIMINATES 100 kHz CLOCK CAUSING MAINT FAULT: TWTA PWR OUT, AND 1 OF 6 POSSIBLE EXEC FAULT INDICATIONS LISTED FOR SYMPTOM NO. 7	105
	ANALOG COMPARATOR 'BCE'	1	BEAM ERP LIGHT ON. SYSTEM SHUTDOWN; EXEC. FAULT.	SHORT U2-13 TO GROUND A21A1A1A4A30		106
		2	ANT TEMP LIGHT ON. MAINT. FAULT.	SHORT U6-5 TO GROUND A21A1A1A4A30		107

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MAJOR UNIT	MAINTENANCE LEVEL	SYMPTOM NO.	SYMPTOM	METHOD OF INSTALLATION	CONDITIONS OR NOTES	IDENT. NO.
MAINT. MONIT. DRWR. (CONT'D)	DETECTOR/ COMPARATOR 'BCR'	1	BEAM & TEST PULSE LIGHT ON. SYSTEM SHUTDOWN, EX. FAULT.	SHORT JUNCTION OF R1 & R2 TO GROUND A21A1A1A4A31		108
	BEAM ACCURACY COUNTER 'BCS'	1	BEAM & TEST PULSE LIGHT ON. SYSTEM SHUTDOWN, EX. FAULT.	SHORT U3-15 TO GROUND A21A1A1A4A32		109
		2	BEAM LIGHT ON. SYSTEM SHUTDOWN. EXEC. FAULT.	SHORT U1-10 TO GROUND A21A1A1A4A32		110
		3	TEST PULSE LIGHT ON. SYSTEM SHUTDOWN. EXEC. FAULT.	SHORT U5-10 TO GROUND A21A1A1A4A32		111
	DIGITAL COMPARATOR 'BCC'	1	FREQ LIGHT ON. SYSTEM SHUTDOWN; EXEC. FAULT.	SHORT U16-13 TO GROUND A21A1A1A4A33		112
		2	BEAM LIGHT ON. SYSTEM SHUTDOWN; EXEC. FAULT.	SHORT U12-5 TO GROUND A21A1A1A4A33		113
		3	TEST PULSE LIGHT ON. SYSTEM SHUTDOWN; EXEC. FAULT.	SHORT U12-13 TO GROUND A21A1A1A4A33		114
		4	FREQ LIGHT ON. SYSTEM SHUTDOWN; EXEC. FAULT.	SHORT U15-5 TO GROUND A21A1A1A4A33		115
		5	FREQ, BEAM, TEST PULSE LIGHTS ON. SYSTEM SHUTDOWN; EXEC. FAULT.	SHORT U11-3 TO GROUND A21A1A1A4A33		116

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MAJOR UNIT	MAINTENANCE LEVEL	SYMPTOM NO.	SYMPTOM	METHOD OF INSTALLATION	CONDITIONS OR NOTES	IDENT. NO.
MAINT. MONIT. DRWR. (CONT'D)	FREQUENCY MONITOR 'BCP'	1	FREQ LIGHT ON. SYSTEM SHUTDOWN; EXEC. FAULT.	CHANGE S2 SETTING (+) OR (-) 1 DIGIT AZ1A1A1A4A34		117
		2	FREQ LIGHT ON. SYSTEM SHUTDOWN; EXEC. FAULT.	REMOVE COAX CABLE CONNECTED TO A4J3 OF AZ1A1A1A4A34		118
	MAINTENANCE INTEGRATOR 'BCP'	1	MOD PHASE LIGHT ON. MAINT. FAULT.	SHORT U16-8 TO GROUND AZ1A1A1A4A1		119
		2	AUX DATA LIGHT ON. MAINT. FAULT.	SHORT U26-6 TO GROUND AZ1A1A1A4A1		120
		3	+20V ELECTRONICS LIGHT ON. MAINT FAULT.	SHORT U29-8 TO GROUND AZ1A1A1A4A2		121
		4	+5V MONITOR LIGHT ON. MAINT FAULT.	SHORT U15-6 TO GROUND AZ1A1A1A4A2		122
		5	ELEC TEMP LIGHT ON. MAINT. FAULT.	SHORT U29-8 TO GROUND AZ1A1A1A4A18		123

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MAJOR UNIT	MAINTENANCE LEVEL	SYMPTOM NO.	SYMPTOM	METHOD OF INSTALLATION	CONDITIONS OR NOTES	IDENT. NO.
MAINT. MONIT. DRWR. (CONT'D)	MAINT. MON. INDIC.	1	MAINT STATUS LIGHT OUT. SYSTEM OPERATING.	SHORT CR4 A2A1A1A4A35	SIMULATES CR4 BURN OUT	124
		2	IDENT ERP LIGHT DOES NOT LIGHT WHEN LAMP TEST IS ACTIVATED.	SHORT CR26 A2A1A1A4A35	SIMULATES CR26 BURN OUT	125
		3	AUX DATA LIGHT DOES NOT LIGHT WHEN LAMP TEST IS ACTIVATED.	SHORT CR30 A2A1A1A4A35	SIMULATES CR30 BURN OUT	126
		4	ELECTRONIC +15 LIGHT DOES NOT LIGHT WHEN LAMP TEST IS ACTIVATED.	SHORT CR34 A2A1A1A4A35	SIMULATES CR34 BURN OUT	127
	CHASSIS PARTS, FRONT PANEL SWITCHES	1	PANEL LAMPS NOT ACTIVATED BY LAMP TEST SWITCH, S3.	REMOVE WIRE BETWEEN E30 AND S3, AT S3	SIMULATES FAULTY S3	128

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MAJOR UNIT	MAINTENANCE LEVEL	SYMPTOM NO.	SYMPTOM	METHOD OF INSTALLATION	CONDITIONS OR NOTES	IDENT. NO.
MONITOR POWER SUPPLY DRAWER	MONITOR RECEIVER ASSEMBLY	1	SYSTEM SHUTDOWN. PREAMBLE, TEST PULSE ACCURACY OR BEAM ACCURACY FAULT INDICATED.	DISCONNECT CABLE FROM A2J5	SIMULATES BAD OSCILLATOR ON REGULATOR BOARD A3U3	129
		2	SYSTEM SHUTDOWN (SAME AS SYMPTOM #1)	DISCONNECT CABLE FROM Z1-R	SIMULATE BAD MIXER	130
		3	SYSTEM SHUTDOWN (SAME AS SYMPTOM #1)	DISCONNECT PWR CONNECTOR TO C-BAND L.O. - A1	SIMULATE BAD C-BAND L.O. MULTIPLIER	131
		4	SYSTEM SHUTDOWN (SAME AS SYMPTOM #1)	REMOVE CRYSTAL FROM C-BAND L.O. - A1	SIMULATE BAD CRYSTAL	132
		5	SYSTEM SHUTDOWN, PREAMBLE LIGHT ON MONITOR PANEL ON.	SHORT A3E2 TO GROUND (LEAD OF A3R1 - 75 OHM RESISTOR IS CONNECTED TO E2)	SIMULATE BAD A3U1	133
		6	SYSTEM SHUTDOWN (SAME AS SYMPTOM #1)	SHORT TO GROUND THE JUMPER BETWEEN PINS 5 AND 9 OF C-BAND L.O. POWER CONNECTOR	CAUSES VCO IN C-BAND L.O. TO UNLOCK	134
		7	SYSTEM SHUTDOWN (SAME AS SYMPTOM #1)	TAPE OR PUSH OUT CONTACT ON J1-F OF MONITOR RECEIVER ASSY	SIMULATE BROKEN WIRE OR BAD CONNECTOR	135
		8	SYSTEM SHUTDOWN. PREAMBLE LIGHT ON MONITOR PANEL ON.	SHORT TP13 (U206-1) OF A2, RCVR MODULE, TO GROUND	SIMULATE A2Q202 FAILURE	136

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MAJOR UNIT	MAINTENANCE LEVEL	SYMPTOM NO.	SYMPTOM	METHOD OF INSTALLATION	CONDITIONS OR NOTES	IDENT. NO.
MONITOR POWER SUPPLY DRAWER (CONT'D)	MONITOR RECEIVER ASSEMBLY (CONT'D)	9	SYSTEM SHUTDOWN. TEST PULSE AND/OR BEAM ACCURACY FAULTS INDICATED.	SHORT COLLECTOR OF A2Q104 TO GROUND	SIMULATE A2Q104 FAILURE	137
		10	SYSTEM SHUTDOWN. PREAMBLE FAULT INDICATED.	SHORT A2TP5 TO GROUND	SIMULATE A2Q201 OSC CIRCUIT FAILURE	138
		11	SYSTEM SHUTDOWN. TEST PULSE ACCURACY AND OR BEAM ACCURACY FAULT.	SHORT A2TP2 TO GROUND	SIMULATE BAD A2U111	139
		12	SYSTEM SHUTDOWN. PREAMBLE FAULT.	SHORT A2TP15 TO GROUND	SIMULATE BAD A2U112	140
		13	SYSTEM SHUTDOWN. PREAMBLE FAULT.	SHORT A2TP7 TO GROUND	SIMULATE BAD A2U206	141
		14	SYSTEM SHUTDOWN. PREAMBLE FAULT.	SHORT A2TP6 TO GROUND	SIMULATE BAD A2U205	142
		15	SYSTEM SHUTDOWN. PREAMBLE, TEST PULSE ACCURACY, AND OR BEAM ACCURACY FAULT.	SHORT TP1 ON REGULATOR BOARD A3 TO GROUND	SIMULATE BAD +12 VOLT REGULATOR	143
		16	SYSTEM SHUTDOWN. PREAMBLE, TEST PULSE ACCURACY, AND OR BEAM ACCURACY FAULT.	SHORT TP2 ON REGULATOR BOARD A3 TO GROUND	SIMULATE BAD -12 VOLT REGULATOR	144
		17	SYSTEM SHUTDOWN. PREAMBLE, TEST PULSE ACCURACY, AND OR BEAM ACCURACY FAULT.	UNSOLDER WIRE FROM A2J4 INTERNAL TO A4	SIMULATE BAD 1ST I.F. STRIP	145
		18	SYSTEM SHUTDOWN. PREAMBLE, TEST PULSE ACCURACY, AND OR BEAM ACCURACY FAULT.	DISCONNECT P1 FROM A2J1	SIMULATE BAD CONNECTOR	146
	5V POWER SUPPLY	1	SYSTEM SHUTDOWN	DISCONNECT AC WIRE FROM POWER SUPPLY TERMINAL BOARD	SIMULATE BAD POWER SUPPLY	147

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MAJOR UNIT	MAINTENANCE LEVEL	SYMPTOM NO.	SYMPTOM	METHOD OF INSTALLATION	CONDITIONS OR NOTES	IDENT. NO.
MONITOR POWER SUPPLY DRAWER (CONT'D)	15V POWER SUPPLY	1	SYSTEM SHUTDOWN.	DISCONNECT -15 VOLT WIRE FROM TERMINAL BOARD	SIMULATE BAD POWER SUPPLY	148
	CHASSIS PARTS	1	SYSTEM SHUTDOWN. MONITOR PANEL LIGHTS OFF. AC PWR LAMP OFF ON MONITOR POWER SUPPLY DRAWER.	DISCONNECT WIRE FROM AC POWER SWITCH	SIMULATE BAD SWITCH	149
		2	SYSTEM SHUTDOWN.	REMOVE FUSE	BLOWN FUSE	150
		3	SYSTEM SHUTDOWN. PREAMBLE, TEST PULSE ACCURACY, AND OR BEAM ACCURACY FAULTS.	REMOVE CONTACT "A" FROM P1	SIMULATE BAD P1	151
COOLING FAN DRAWER	CHASSIS PARTS	1	FAN OFF - OVER TEMPERATURE FAULT INDICATED IF CABINET EXHAUST TEMPERATURE EXCEEDS +50°C.	REMOVE FAN FUSE ON TOP REAR OF CHASSIS	BAD FUSE	152
		2	SAME AS SYMPTOM 1	REMOVE AC WIRE FROM TERMINAL BOARD IN FAN DRAWER	SIMULATE BROKEN WIRE	153
		3	AIR BLOCKED - OVER TEMPERATURE FAULT INDICATED IF CABINET EXHAUST TEMPERATURE EXCEEDS +50°C	COVER AIR FILTER WITH CARDBOARD OR HEAVY PAPER	SIMULATE DIRTY FILTER	154

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MAJOR UNIT	MAINTENANCE LEVEL	SYMPTOM NO.	SYMPTOM	METHOD OF INSTALLATION	CONDITIONS OR NOTES	IDENT. NO.
ANTENNA	SCAN SWITCH	1	SCAN SWITCH FAULT IND. DS1 ON INT. SCAN SWITCH MONITOR DS5 ON SCAN SWITCH MONITOR	MASK OFF PIN 3 OF J6 ON S13	5V SUPPLY TO SWITCH	155
		2	SCAN SWITCH FAULT IND. DS1 ON INT. SCAN SWITCH MONITOR DS5 ON SCAN SWITCH MONITOR	MASK OFF PINS 2 AND 15 OF J6 ON S13	CONTROL TO SWITCH	156
		3	SCAN SWITCH FAULT IND. DS1 ON INT. SCAN SWITCH MONITOR DS5 ON SCAN SWITCH MONITOR	MASK OFF PIN 6 OF J6 ON S13	MONITOR FROM SWITCH	157
		4	SCAN SWITCH FAULT IND. DS1 ON INT. SCAN SWITCH MONITOR DS5 ON SCAN SWITCH MONITOR	MASK OFF PIN 4 OF J6 ON S13	-40V SUPPLY TO SWITCH	158
		5	SCAN SWITCH FAULT IND. DS1 ON SCAN SWITCH MONITOR EXPANDER BOARD #1 DS5 ON SCAN SWITCH MONITOR BOARD	MASK OFF PIN 3 OF J6 ON S5	5V SUPPLY TO SWITCH	159
		6	SCAN SWITCH FAULT IND. DS1 ON SCAN SWITCH MONITOR EXPANDER BOARD #1 DS5 ON SCAN SWITCH MONITOR BOARD	MASK OFF PINS 2 AND 15 OF J6 ON S5	CONTROL TO SWITCH	160
		7	SCAN SWITCH FAULT IND. DS1 ON SCAN SWITCH MONITOR EXPANDER BOARD #1 DS5 ON SCAN SWITCH MONITOR BOARD	MASK OFF PIN 6 OF J6 ON S5	MONITOR FROM SWITCH	161
		8	SCAN SWITCH FAULT IND. DS1 ON SCAN SWITCH MONITOR EXPANDER BOARD #1 DS5 ON SCAN SWITCH MONITOR BOARD	MASK OFF PIN 4 ON J6 ON S5	-40 V SUPPLY TO SWITCH	162
		9	SCAN SWITCH FAULT IND. DS1 ON SCAN SWITCH MONITOR EXPANDER BOARD #2 DS5 ON SCAN SWITCH MONITOR BOARD	MASK OFF PIN 3 OF J6 ON S9	5V SUPPLY TO SWITCH	163

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MAJOR UNIT	MAINTENANCE LEVEL	SYMPTOM NO.	SYMPTOM	METHOD OF INSTALLATION	CONDITIONS OR NOTES	IDENT. NO.
ANTENNA (CONT'D)	SCAN SWITCH (CONT'D)	10	SCAN SWITCH FAULT IND. DS1 ON SCAN SWITCH MONITOR EXPANDER BOARD #2 DS5 ON SCAN SWITCH MONITOR BOARD	MASK OFF PINS 2 AND 15 ON J6 OF S9	CONTROL TO SWITCH	164
		11	SCAN SWITCH FAULT IND. DS1 ON SCAN SWITCH MONITOR EXPANDER BOARD #2 DS5 ON SCAN SWITCH MONITOR BOARD	MASK OFF PIN 6 OF J6 ON S9	MONITOR FROM SWITCH	165
	SCAN MON.	1	SCAN MON. FAULT INDIC. DS1 ON SCAN CONTROL COMPARATOR	REMOVE FUSE ON SCAN MON.	AC TO MONITORS	166
		2	SCAN SWITCH FAULT INDIC. DS5 ON SCAN SWITCH MONITOR	MASK OFF PINS 9 AND 22 ON J6 OF SCAN MOD.	+5V	167
		3	SCAN SWITCH FAULT INDIC. DS5 ON SCAN SWITCH MONITOR	MASK OFF PINS 10 AND 23 OF J6 ON SCAN MOD.	+24V	168
		4	BEAM ACC. INDICATOR	MASK OFF PINS 1 AND 14 OF J6 ON SCAN MOD.	SIGNAL INPUT	169
	ANT. SELECT SWITCH	1	ERP INDICATORS FOR SEVERAL ANTENNAS	MASK OFF PINS 4 AND 12 OF J6 ON ANT. SEL. SWITCH	-40V LINE	170
BEAM STEERING	SCAN CONTROL	1	SCAN ELECTRONICS FAULT. DS3 ON SCAN CONTROL COMPARATOR	MASK OFF PIN B23 ON SCAN CONTROL BD. IN BM STEERING	CONTROL TO SCAN MOD	171
		2	SCAN ELECTRONICS FAULT DS2 AND DS4 ON SCAN CONTROL COMPARATOR	MASK OFF PIN B32 ON SCAN CONTROL BD	100 kHz CLOCK TO MONITOR	172

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BEAM STEERING (CONT'D)	SCAN CONTROL COMP.	1	SCAN ELEC. FAULT DS3, DS4 ON SCAN CONT. COMP.	GND TP2 OF SCAN CONTRCL MONIT.	SWITCH CONT. FAULT	173
	SCAN CONTROL MONITOR	1	SCAN ELEC. FAULT DS3, DS4 ON SCAN CONT. COMP.	TIE TP3 OF SCAN CONTROL MONITOR TO VCC	CC CNTR FAULT	174
		2	SCAN ELEC. FAULT DS3, DS4 ON SCAN CONTROL COMP.	MASK OFF PIN B24 ON SCAN CONTROL MONITOR	SCAN MOD. CONTROL FAULT	175
	SCAN SWITCH DRIVER	1	SCAN ELECTRONICS FAULT DS1 ON SCAN SWITCH DRIVER	MASK OFF PIN A8 ON SCAN SWITCH DRIVER	SWITCH DRIVER MONITOR FAULT	176
	INTERMEDIATE SCAN SWITCH DRIVER	1	SCAN ELECTRONICS FAULT DS1 ON INT. SCAN SWITCH DRIVER	MASK OFF PIN B29 ON INT. SCAN SWITCH DRIVER	SWITCH DRIVER MONITOR FAULT	177
	SCAN SWITCH MONITOR	1	SCAN SWITCH FAULT DS2, DS5 ON SCAN SWITCH MONITOR	MASK OFF PIN B10 ON SCAN SWITCH MONITOR	SWITCH MONITOR FAULT	178
		2	SCAN SWITCH FAULT DS2, DS5 ON SCAN SWITCH MONITOR	MASK OFF PIN B24 ON SCAN SWITCH MONITOR	SWITCH MONITOR FAULT	179
	SCAN SWITCH MON. EXPANDER	1	SCAN SWITCH FAULT DS5 ON S.S. MONITOR DS3 ON S.S. MON. EXP.	MASK OFF PIN B26 ON SCAN SWITCH MONITOR EXPAND ON	SWITCH MONITOR FAULT	180
	INT. SCAN SWITCH MON.	1	SCAN SWITCH FAULT DS2 ON INT. SCAN SWITCH MONITOR	MASK OFF PIN B11 ON INT. SCAN SWITCH MONITOR	SWITCH MONITOR FAULT	181
	10 MHz OSC.	1	SCAN ELECTRONICS FAULT DS4 ON SCAN CONT. COMP. DS1 ON SCAN CONT. MONITOR	MASK OFF PIN B35 OF SCAN CONTROL MONITOR	CLOCK FAULT	182

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BEAM STEERING (CONT'D)	CHASSIS PARTS	1	STEERING ELECT. FAULT SCAN SWITCH FAULT SCAN MOD. FAULT ALL FAULT INDICATORS ON BEAM STEERING	TAPE LAMP TEST SWITCH IN "TEST" POSITION	SHORTED LAMP TEST SWITCH	183
		2	SYSTEM SHUTDOWN - BEAM ACCURACY, SCAN CONTROL, SCAN SWITCH, AND/OR BEAM ERP FAULT	DISCONNECT WIRE FROM XA1-B35 (10 MHz OSCILLATOR OUTPUT) OR INSULATE OUTPUT PIN OF MODULE	SIMULATE BAD CONNECTOR	184
		3	SYSTEM SHUTDOWN - BEAM ACCURACY, BEAM ERP, SCAN SWITCH, AND/OR SCAN MODULATOR FAULT	PUSH OUT PIN H OF J1 (POWER CONNECTOR)	SIMULATE BAD CONNECTOR	185
ANT. POWER SUPPLIES	5V POWER SUPPLY	1	ANT. POWER SUPPLY FAULT (+5V)	ADJUST +5V SUPPLY TO +1V		186
MONITOR HORN ASSY	RF DETECTOR	1	SYSTEM SHUTDOWN - BEAM ERP FAULT	LOOSEN OR INSULATE OUTPUT CONNECTION		187
	BANDPASS FILTER	1	SYSTEM SHUTDOWN - BEAM ERP AND/OR ACCURACY FAULT	LOOSEN OR INSULATE OUTPUT CONNECTOR		188

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MISCELLANEOUS	LPBD #1	1	ELEVATION SHUTDOWN - SYSTEM TIMING FAULT	SHORT R14 OF LPB A3 IN ELEVATION SHELTER SIGNAL JUNCTION BOX		189
		2	ELEVATION SHUTDOWN - (MAY TAKE HOURS) SYSTEM TIMING FAULT. SYNC PRESENCE MAINTENANCE FAULT LIGHT (IMMEDIATELY)	SHORT R13 OF LPB A3 IN ELEVATION SHELTER SIGNAL JUNCTION BOX		190
		3	DATA LINK FAULT	LIFT R5 AND R6 ON LPB A3 IN ELEVATION SHELTER	(OR JUMPER TB1-d TO TB1-6)	191
	LPBD #2	1	SYSTEM SHUTDOWN - BEAM ERP FAULT	JUMPER TB1-1 TB1-2 OF LPB A5 IN EL SHELTER SIGNAL JUNCT. BOX		192
	LPBD #4	1	ANTENNA +5V P.S. MAINTENANCE FAULT LIGHT	RAISE R7 OR DISCONNECT WIRE FROM TB2-7 OF LPB A1 IN ELEVATION SHELTER SIG. JUNCT. BOX		193
		2	ANTENNA +24 P.S. MAINTENANCE FAULT LIGHT	RAISE R7 OR DISCONNECT WIRE FROM TB2-9 OF LPB A1 IN EL SHELTER SIG. JUNCTION BOX		194

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MISCELLANEOUS (CONT'D)	LPBD #5	1	ANTENNA +5V P.S. MAINTENANCE FAULT LIGHT	RAISE R7 OR DISCONNECT WIRE FROM TB2-7 OF LPB A2 IN EL ANTENNA CASE		195
		2	ANTENNA -40V P.S. MAINTENANCE FAULT LIGHT	RAISE R11 OR DISCONNECT WIRE FROM TB2-11 OF LPB A2 IN EL ANTENNA CASE		196
		3	ANTENNA +24V P.S. MAINTENANCE FAULT LIGHT	RAISE R9 OR DISCONNECT WIRE FROM TB2-9 OF LPB A2 IN EL ANTENNA CASE		197
	POWER DISTRIBUTION	1	SYSTEM SHUTDOWN	DISCONNECT WIRE FROM CB26	ANTENNA ELECTRONICS POWER	198
		2	SYSTEM SHUTDOWN	DISCONNECT WIRE FROM CB22	ELECTRONICS CABINET POWER	199
		3	SYSTEM SHUTDOWN	DISCONNECT WIRE FROM CB21 (AZ SHELTER)	AUX CABINET POWER	200

Appendix E

Reliability and Maintainability
Predictions Prepared for the MLS Basic
and General Aviation Airborne Equipment

Contract No.
DOT FA-72WA-2801

prepared by

The Bendix Corporation
Communications Division
Towson, Maryland 21204

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APPENDIX E

RELIABILITY AND MAINTAINABILITY PREDICTIONS PREPARED FOR THE MLS BASIC AND GENERAL AVIATION AIRBORNE EQUIPMENT

E.1 INTRODUCTION

This Appendix presents the results of the reliability predictions prepared for the MLS Basic Narrow and Small Community airborne equipments.

E.2 REQUIREMENTS

The reliability and maintainability requirements for the Basic Narrow airborne equipment are specified in FAA-ER-700-07, Table 11-7A. The requirements are a mean-time-between-failures (MTBF) of 1500 hours, mean-elapsed-time, maintenance (MET) of 0.25 hours and maintenance-man-hours/operating-hour (MMH/OH) of 0.0005.

E.3 SUMMARY RESULTS

E.3.1 Basic Narrow Airborne Equipment

The result of the reliability prediction is an MTBF of 1,870 hours for the active angle equipment less the auxiliary data display, and 1,290 hours with the auxiliary data display. The prediction is based on an ambient temperature of 30°C, considered a typical environment for the equipment. The equipment is designed to be fully operational at the maximum specified temperature. For completeness, the variability of the MTBF with temperature over the possible operating temperature range is shown in Figure E-1. The detailed reliability block diagram for the active Basic Narrow airborne equipment at 30°C is shown in Figure E-2.

The MTBF for the executive monitor equipment is 23,300 hours. Combining this with the results for the active equipment, the total system MTBF is 1,700 hours without the auxiliary

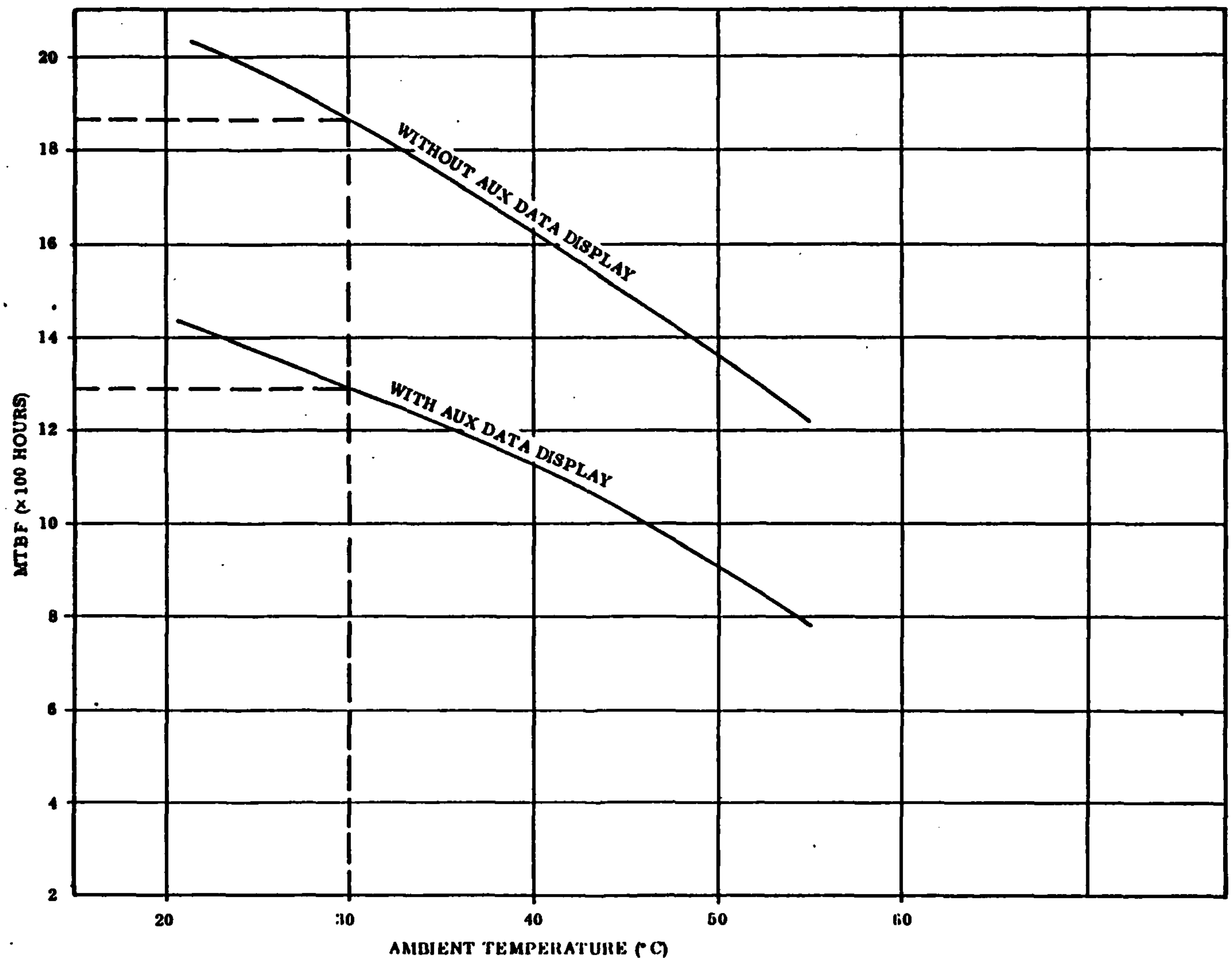

FIGURE E-1. BASIC NARROW AIRBORNE EQUIPMENT

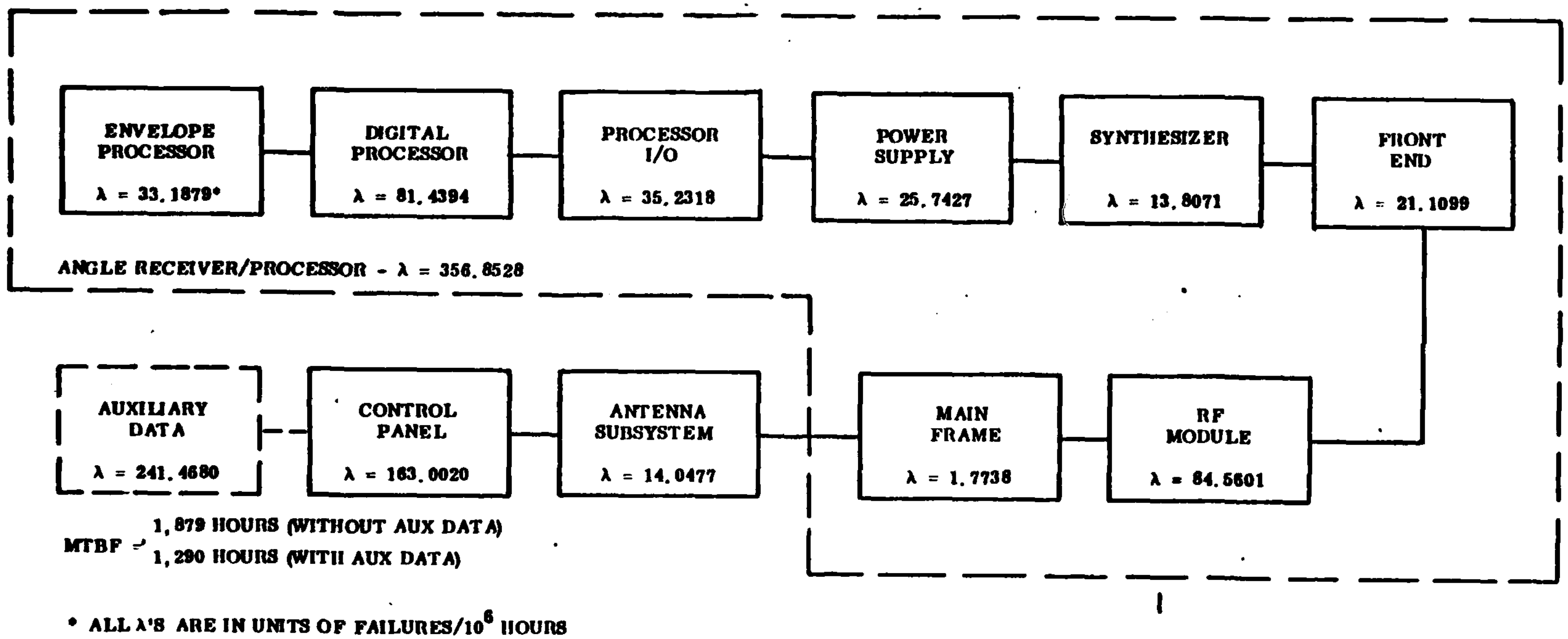

FIGURE E-2. BASSIC NARROW AIRBORNE EQUIPMENT

data display and 1,200 hours with the auxiliary data display.

Maintenance monitoring equipment has been added to aid in fault localization and isolation. Failures in this equipment do not cause degradation of system operation. A prediction, however was performed for this equipment for use in determining system maintainability characteristics. The predicted MTBF for the maintenance monitoring equipment is 79,000 hours.

Estimates of maintenance times have been made for all elements of the Basic Narrow airborne equipment. The resultant mean-time-to-repair (MTTR) values are shown in the following table, where MTTR is defined as the time required to repair after the equipment has been removed from the aircraft.

UNIT	($F/10^6$ hrs.)	MTTR (HRS)
Angle Rcvr/Processor	412.4868	0.50
Control Panel	163.0020	0.25
AUX Data Display	241.4680	0.25
System	816.9568	0.38

The MMH/OH (average maintenance hours per operating hour) is therefore

$$MMH/OH = F.R. \times MTTR = 0.00032$$

Also, the MET, which is the average maintenance time for localizing and replacing the entire airborne equipment, is estimated to be 0.17 hours.

E.3.2 Small Community Airborne Equipment

The predicted MTBF for the Small Community airborne equipment is 1,590 hours, computed for an ambient temperature of 30°C. Figure E-3 illustrated the relationship of MTBF to ambient temperature. Figure E-4 shows the detailed reliability block diagram for this configuration at 30°C.

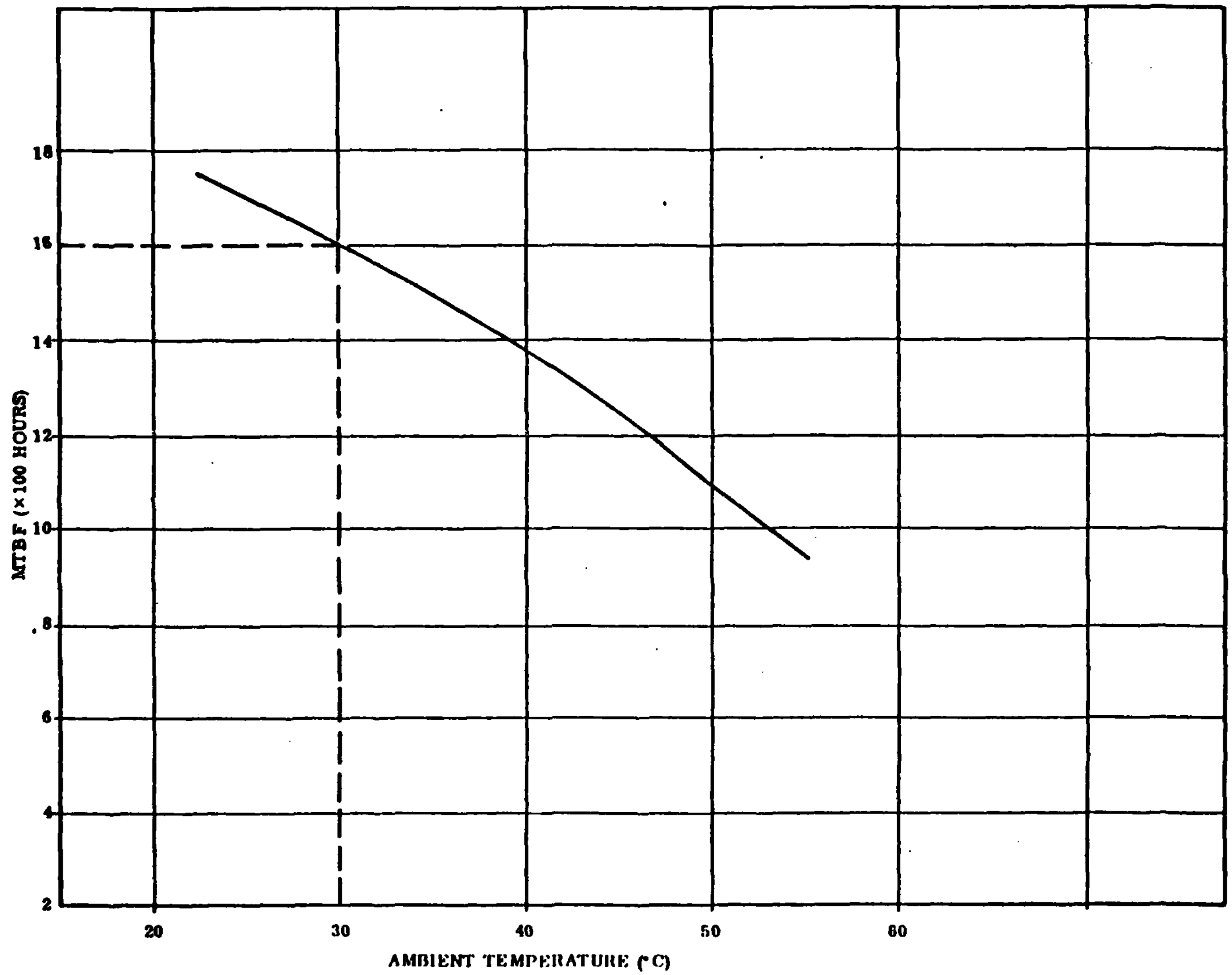

FIGURE E-3. SMALL COMMUNITY AIRBORNE EQUIPMENT

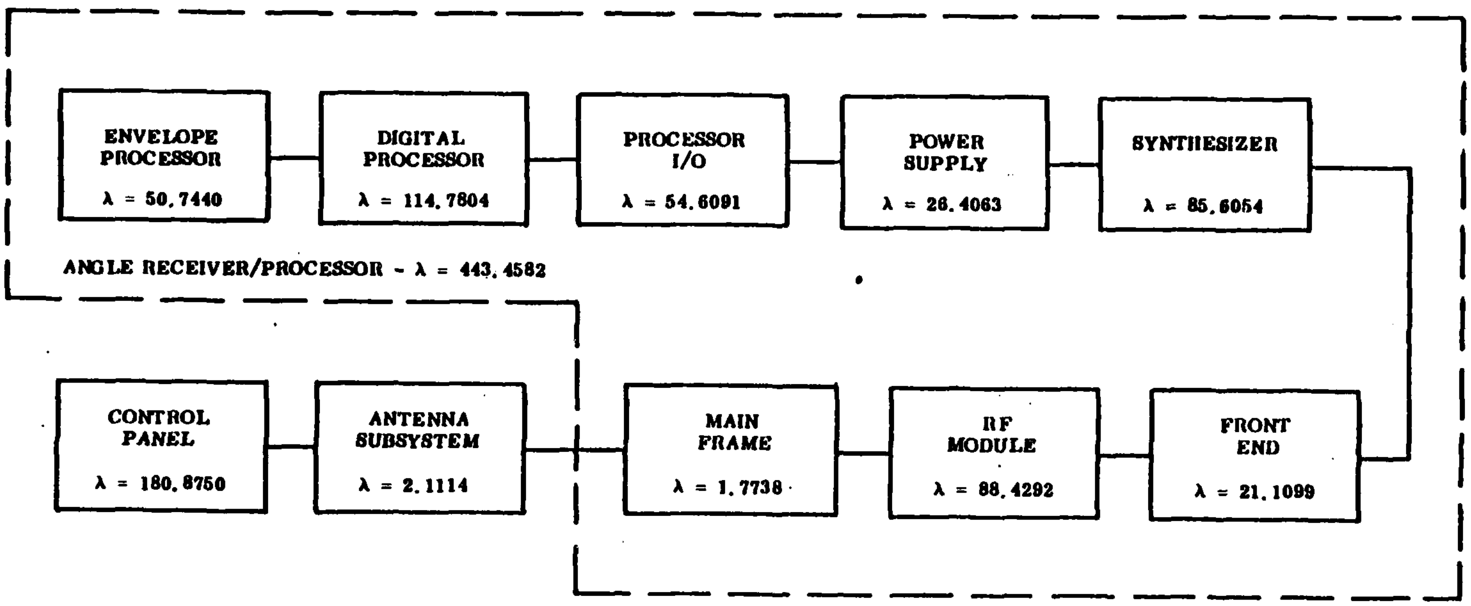

FIGURE E-4. SMALL COMMUNITY AIRBORNE EQUIPMENT

AD-A081 133 BENDIX CORP BALTIMORE MD COMMUNICATIONS DIV F/G 17/7
MICROWAVE LANDING SYSTEM (MLS). PHASE III (BASIC NARROW AND SMA--ETC(U)
JAN 78 DOT-FA72WA-2801
UNCLASSIFIED MLS-BCD-R-2801-1-VOL-2 NL

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The estimated MTTR parameters are shown in the following table.

UNIT	($F/10^6$hrs.)	MTTR (HRS)
Angle Rcvr/Processor	443.4582	0.50
Control Panel	180.8750	0.25
System	624.3332	0.43

The computed MMH/OH is 0.00027 and the estimated MET is 0.17 hours.

E.3.3 Prediction Details

The source of failure rates used in the prediction is Mil-HDBK-217B. The Airborne, inhabited environmental factors contained in this source were applied to account for the intended operating environment.

An operating ambient temperature of 30°C was assumed for both the Basic Narrow and the Small Community prediction. This is estimated to be the typical temperature at which the equipment will operate. Temperature rises within the equipment were applied on a subassembly level depending on the location of the subassembly within the equipment and are based on measured values. The temperature rises which were used range from 0°C to 35°C. These temperature rises were added to the ambient temperature in performing the prediction; that is, for an assembly with a 20°C internal rise, the 30°C prediction was made using 50°C to enter the part failure rate tables.

Detailed computer listing of the reliability predictions are given in Supplement A. Two separate listings are included, one for the Basic Narrow and one for the Small Community equipments. Each lisitng shows a complete part breakdown for each subassembly/board in the equipment, the operating electrical stress and the part failure rates for four different temperatures, 0°C, 25°C, 30°C and 54°C. The last page of each computer listing shows a summary of each subassembly/board failure rate and the total failure rate of the equipment.

SUPPLEMENT A

Detailed Computer Listings of Reliability Predictions for Basic Narrow and the Small Community Airborne Equipment

CONTRACT ILS PROGRAM EQUIPMENT BASIC AIRBORNE EQUIP DATE 2/26/76 REV

ASSEMBLY ACTIVE EQUIP SUBASSEMBLY ANGLE REC/PROC BOARD ENVELOPE PROC INTERNAL TEMPERATURE RISE 20

ENVIRONMENT/TEMPERATURE CONDITION PAIRS FOLLOW
(F.R.1) AIRBORNE,INHABITED (F.R.2) AIRBORNE,INHABITED (F.R.3) AIRBORNE,INHABITED (F.R.4) AIRBORNE,INHABITED
0 DEGREES C 25 DEGREES C 30 DEGREES C 54 DEGREES C

CKT SYMBL	PART DESCR	PART TYPE	NON-STD PART NO.	PERCT STRESS	QTY	F.R. SOURCE	REV	ERROR CODE	(F.R.1)	(F.R.2)	(F.R.3)	(F.R.4)
27 47	MICROELEC. SSI/MSI			0.	4				2.23012	2.39460	2.45221	2.97946
26 37	MICROELEC. SSI/MSI			0.	4				1.74689	1.87407	1.91162	2.22263
5 23	MICROELEC. LINEAR			0.	4				2.61911	2.91876	3.07379	5.14721
21 38	MICROELEC. LINEAR			0.	2				2.81208	3.24355	3.46678	6.45237
3 14	MICROELEC. SSI/MSI			0.	2				1.51802	2.00917	2.26327	5.66181
44 46	MICROELEC. SSI/MSI			0.	3				2.12364	2.31456	2.38144	2.93540
6 22	MICROELEC. SSI/MSI			0.	2				0.77748	0.81982	0.83465	0.95749
13 35	MICROELEC. SSI/MSI			0.	2				0.77748	0.81982	0.83465	0.95749
20	MICROELEC. SSI/MSI			0.	1				0.48563	0.51754	0.52872	0.62130
41 42	MICROELEC. SSI/MSI			0.	2				0.84377	0.89301	0.91026	1.05313
16	MICROELEC. SSI/MSI			0.	1				0.26025	0.27031	0.27383	0.30303
4	MICROELEC. SSI/MSI			0.	1				0.20225	0.20855	0.21075	0.22901
12 10	MICROELEC. SSI/MSI			0.	2				1.46596	1.60159	1.64909	2.04262
7	MICROELEC. SSI/MSI			0.	1				0.23437	0.24265	0.24555	0.26958
11	ROM MEMORY			0.	1				1.54034	3.78462	6.86435	17.97064
33 34	MICROELEC. SSI/MSI			0.	4				2.39221	3.02951	3.35923	7.76906
	CONNECTOR			0.	1				0.19437	0.36812	0.41531	0.72414
1 15	RESISTOR(FIXED-COMP)	RCR		10.	8				0.00487	0.01187	0.01418	0.03332
25 34	RESISTOR(FIXED-COMP)	RCR		8.	4				0.00235	0.00571	0.00682	0.01597
32 39	RESISTOR(FIXED-COMP)	RCR		1.	4				0.00207	0.00498	0.00594	0.01377
15 25	RESISTOR(FIXED-COMP)	RCR		1.	3				0.00171	0.00411	0.00490	0.01136
9	RESISTOR(FIXED-COMP)	RCR		31.	1				0.00089	0.00223	0.00268	0.00650
30	RESISTOR(FIXED-COMP)	RCR		10.	2				0.00134	0.00326	0.00390	0.00916
31	RESISTOR(FIXED-COMP)	RCR		10.	1				0.00061	0.00148	0.00177	0.00416
15	RESISTOR(FIXED-COMP)	RCR		10.	1				0.00061	0.00148	0.00177	0.00416
15	RESISTOR(FIXED-COMP)	RCR		10.	1				0.00061	0.00148	0.00177	0.00416
16	RESISTOR(FIXED-COMP)	RCR		1.	1				0.00052	0.00125	0.00148	0.00344
19	RESISTOR(FIXED-COMP)	RCR		10.	1				0.00061	0.00148	0.00177	0.00416
18	RESISTOR(FIXED-COMP)	RCR		10.	1				0.00061	0.00148	0.00177	0.00416
19	RESISTOR(FIXED-COMP)	RCR		1.	1				0.00052	0.00125	0.00148	0.00344
25 32	RESISTOR(POWER-FILM)	RWP		6.	4				0.02866	0.03597	0.03765	0.04682
34 76	RESISTOR(POWER-FILM)	RWP		8.	4				0.02866	0.03597	0.03765	0.04682
0 9	DIODE (ZENER)		1N757A	40.	1				0.53725	0.66081	0.69216	0.90911
32 36	CAPACITOR(CERAMIC)	CK		10.	3				0.25108	0.26924	0.27302	0.29105
15 39	CAPACITOR(CERAMIC)	CK		10.	16				1.33908	1.43593	1.45613	1.55709
9 25	CAPACITOR(CERAMIC)	CY		2.	2				0.16145	0.17313	0.17557	0.18774
40	CAPACITOR(CERAMIC)	CK		1.	1				0.08071	0.08654	0.08776	0.09385
30	CAPACITOR(CERAMIC)	CK		1.	1				0.08071	0.08654	0.08776	0.09385
5	CAPACITOR(CERAMIC)	CK		1.	1				0.08071	0.08654	0.08776	0.09385
15	CAPACITOR(CERAMIC)	CK		4.	1				0.08089	0.08675	0.08797	0.09407
12 19	CAPACITOR(CERAMIC)	CK		1.	3				0.24212	0.25963	0.26328	0.28154
17	CAPACITOR(CERAMIC)	CK		1.	1				0.08071	0.08654	0.08776	0.09385
1	CAPACITOR(CERAMIC)	CK		1.	1				0.08071	0.08654	0.08776	0.09385

TOTAL FAILURE RATES FOR THIS LEVEL ARE........ 25.33395 30.74438 33.18791 62.24434

CONTRACT MLS PROGRAM EQUIPMENT BASIC AIRBORNE EQUIP DATE 2/26/76 REV

ASSEMBLY ACTIVE EQUIP SUBASSEMBLY ANGLE DEC/PROC BOARD DIGITAL PROC INTERNAL TEMPERATURE RISE 20

ENVIRONMENT/TEMPERATURE CONDITION PAIRS FOLLOW
(F.R.1) AIRBORNE,INHABITED 0 DEGREES C
(F.R.2) AIRBORNE,INHABITED 25 DEGREES C
(F.R.3) AIRBORNE,INHABITED 30 DEGREES C
(F.R.4) AIRBORNE,INHABITED 54 DEGREES C

CKT SYMBL	PART DESCR	PART TYPE	NON-STD PART NO.	PERCT STRESS	QTY	F.R. SOURCE	REV	ERROR CODE	(F.R.1)	(F.R.2)	(F.R.3)	(F.R.4)
	MICROELEC. LSI			0.	1	6			25.00000	25.00000	25.00000	25.00000
	RAM MEMORY			0.	2				4.60497	6.03601	6.51336	10.27084
	ROM MEMORY			0.	3				16.61782	21.35752	22.93851	35.38353
	MICROELEC. SSI/MSI			0.	1				0.67191	0.72977	0.75004	0.91793
	MICROELEC. SSI/MSI			0.	1				0.89401	0.97784	1.00720	1.25042
	MICROELEC. SSI/MSI			0.	3				1.26566	1.33952	1.36539	1.57969
	MICROELEC. SSI/MSI			0.	1				0.44172	0.46852	0.47791	0.55566
	MICROELEC. SSI/MSI			0.	1				0.69917	0.76139	0.78319	0.96372
	MICROELEC. SSI/MSI			0.	4				1.68754	1.78602	1.82052	2.10626
	RAM MEMORY			0.	4				4.43729	11.23606	14.49800	54.16652
	MICROELEC. SSI/MSI			0.	2				1.11506	1.19730	1.22611	1.46473
	MICROELEC. SSI/MSI			0.	3				1.16623	1.22973	1.25197	1.43623
	MICROELEC. SSI/MSI			0.	1				0.55753	0.59865	0.61305	0.73236
	MICROELEC. LINEAR			0.	1				0.60150	0.66809	0.70255	1.16339
	MICROELEC. SSI/MSI			0.	1				0.71216	0.77651	0.79905	0.98575
	MICROELEC. SSI/MSI			0.	1				0.26025	0.27031	0.27383	0.30303
	MICROELEC. SSI/MSI			0.	1				0.26025	0.27031	0.27383	0.30303
	MICROELEC. SSI/MSI			0.	1				0.26025	0.27031	0.27383	0.30303
	CAPACITOR(TANT. EL.) CSR			30.	1				0.00805	0.00963	0.01014	0.01452
	CONNECTOR			0.	1				0.30936	0.58589	0.66101	1.15252
	QUARTZ CRYSTAL			0.	1				0.20000	0.20000	0.20000	0.20000

TOTAL FAILURE RATES FOR THIS LEVEL ARE........ 61.77066 75.76927 81.43937 140.25293

CONTRACT MLS PROGRAM   EQUIPMENT BASIC AIRBORNE EQUIP   DATE 2/26/76   REV

ASSEMBLY ACTIVE EQUIP   SUBASSEMBLY ANGLE REC/PROC   BOARD PROCESSOR I/O   INTERNAL TEMPERATURE RISE 20

ENVIRONMENT/TEMPERATURE CONDITION PAIRS FOLLOW
(F.R.1) AIRBORNE,INHABITED 0 DEGREES C   (F.R.2) AIRBORNE,INHABITED 25 DEGREES C   (F.R.3) AIRBORNE,INHABITED 30 DEGREES C   (F.R.4) AIRBORNE,INHABITED 54 DEGREES C

CKT SYMBL	PART DESCR	PART TYPE	NON-STD PART NO.	PERCT STRESS	QTY	F.R. SOURCE	REV	ERROR CODE	(F.R.1)	(F.R.2)	(F.R.3)	(F.R.4)
U32	ROM MEMORY			0.	1				1.54036	3.78662	4.86435	17.97064
U31	ROM MEMORY			0.	1				0.63942	1.61312	2.08028	7.76145
U44	MICROELEC. LINEAR			0.	5				4.93647	5.59792	5.94013	10.51708
U45	MICROELEC. LINEAR			0.	1				0.60150	0.66809	0.70255	1.16339
U43	MICROELEC. LINEAR			0.	4				2.91471	3.26220	3.44198	5.84648
U39	MICROELEC. SSI/MSI			0.	4				2.23012	2.39460	2.45221	2.92946
U11	MICROELEC. SSI/MSI			0.	1				0.44172	0.46852	0.47791	0.55566
U40	MICROELEC. SSI/MSI			0.	1				0.55753	0.59865	0.61305	0.73236
U48	MICROELEC. SSI/MSI			0.	1				0.36364	0.38235	0.38890	0.44319
U26	MICROELEC. SSI/MSI			0.	5				3.28777	3.56590	3.66332	4.47031
U24	RAM MEMORY			0.	1				1.10932	2.80901	3.62450	13.54163
U21	MICROELEC. SSI/MSI			0.	1				0.67191	0.72977	0.75004	0.91793
U7	MICROELEC. SSI/MSI			0.	2				0.60342	0.62990	0.63917	0.71600
U9	MICROELEC. SSI/MSI			0.	1				0.26025	0.27031	0.27383	0.30303
U10	MICROELEC. SSI/MSI			0.	1				0.60543	0.65326	0.67001	0.80878
U12	MICROELEC. SSI/MSI			0.	1				0.26025	0.27031	0.27383	0.30303
U14	MICROELEC. SSI/MSI			0.	1				0.00000	0.00000	0.00000	0.00000
U15	MICROELEC. LINEAR			0.	1				0.60150	0.66809	0.70255	1.16339
U19	MICROELEC. SSI/MSI			0.	1				0.30171	0.31495	0.31959	0.35800
U13	MICROELEC. SSI/MSI			0.	1				0.38874	0.40991	0.41732	0.47874
	TRANSISTOR (GE)	NPN		25.	2				0.78662	1.49053	1.71936	4.33811
	DIODE (SI)	GP		10.	4				0.30493	0.51551	0.56777	0.87764
	RESISTOR(FIXED-COMP)	RCR		2.	12				0.00634	0.01524	0.01817	0.04219
	RESISTOR(FIXED-COMP)	RCR		20.	4				0.00291	0.00721	0.00864	0.02059
	RESISTOR(FIXED-COMP)	RCR		3.	10				0.00538	0.01295	0.01544	0.03591
	RESISTOR(FIXED-COMP)	RCR		2.	4				0.00211	0.00508	0.00606	0.01406
	RESISTOR(FIXED-COMP)	RCR		33.	2				0.00184	0.00464	0.00558	0.01356
	RESISTOR(FIXED-COMP)	RCR		10.	2				0.00122	0.00297	0.00354	0.00833
	RESISTOR(FIXED-COMP)	RCR		15.	2				0.00133	0.00327	0.00391	0.00926
	RESISTOR(POWER-FILM)	RNR		1.	2				0.01329	0.01658	0.01733	0.02142
U30	RESISTOR(FIXED-COMP)	RCR		1.	14				0.00726	0.01744	0.02078	0.04818
	CONNECTOR			0.	1				0.25732	0.48733	0.54981	0.95864
TOTAL FAILURE RATES FOR THIS LEVEL ARE........									23.70623	31.67214	35.23183	77.36822

CONTRACT MLS PROGRAM EQUIPMENT BASIC AIRBORNE EQUIP DATE 2/26/76 REV

ASSEMBLY ACTIVE EQUIP SUBASSEMBLY ANGLE REC/PROC BOARD POWER SUPPLY INTERNAL TEMPERATURE RISE 20

ENVIRONMENT/TEMPERATURE CONDITION PAIRS FOLLOW
(F.R.1) AIRBORNE,INHABITED 0 DEGREES C (F.R.2) AIRBORNE,INHABITED 25 DEGREES C (F.R.3) AIRBORNE,INHABITED 30 DEGREES C (F.R.4) AIRBORNE,INHABITED 54 DEGREES C

CKT SYMBL	PART DESCR	PART TYPE	NON-STD PART NO.	PERCT STRESS	QTY	F.R. SOURCE	REV	ERROR CODE	(F.R.1)	(F.R.2)	(F.R.3)	(F.R.4)
U1	MICROELEC. LINEAR			0.	1				0.52891	0.58464	0.61347	0.99907
U2	MICROELEC. LINEAR			0.	1				0.42923	0.47095	0.49253	0.78119
Q1	TRANSISTOR (SI)	PNP		30.	1				0.51296	0.69373	0.73690	1.00390
Q2	TRANSISTOR (SI)	PNP		4.	1				0.30313	0.42952	0.45816	0.61539
Q3	TRANSISTOR (SI)	NPN		3.	1				0.10363	0.13880	0.14670	0.19034
Q4	TRANSISTOR (SI)	NPN		3.	1				0.10363	0.13880	0.14670	0.19034
Q5	TRANSISTOR (SI)	NPN		25.	1				0.15161	0.19881	0.21004	0.27818
Q6	TRANSISTOR (SI)	NPN		25.	1				0.15161	0.19881	0.21004	0.27818
Q7	TRANSISTOR (SI)	NPN		1.	1				0.09983	0.13422	0.14192	0.18425
CR1	DIODE (SI)	GP		23.	3				0.51997	0.83482	0.91243	1.38313
CR2	DIODE (ZENER)			1.	1				0.33147	0.41244	0.42958	0.51871
CR3	DIODE (SI)	GP		1.	1				0.05542	0.09799	0.10872	0.17259
CR4	DIODE (SI)	GP		37.	1				0.17259	0.26768	0.29179	0.45145
CR5 6	DIODE (SI)	GP		45.	2				0.42747	0.65926	0.72059	1.16658
CR7/11	DIODE (SI)	GP		14.	2				0.17418	0.28934	0.31779	0.48694
CR14	DIODE (SI)	GP		5.	4				0.25631	0.44384	0.49075	0.76906
CR16	DIODE (SI)	GP		2.	2				0.11499	0.20225	0.22419	0.35470
CR25	DIODE (SI)	GP		1.	2				0.11083	0.19598	0.21743	0.34517
Q11	TRANSISTOR (SI)	NPN		1.	1				0.09983	0.13422	0.14192	0.18425
R1	RESISTOR(FIXED-COMP)	RCR		10.	1				0.00061	0.00148	0.00177	0.00416
R2	RESISTOR(FIXED-COMP)	RCR		1.	1				0.00052	0.00125	0.00148	0.00344
R3	THERMISTOR	RTH		0.	1				0.52000	0.52000	0.52000	0.52000
R4	RESISTOR(FIXED-COMP)	RCR		1.	1				0.00052	0.00125	0.00148	0.00344
R5	RESISTOR(FIXED-COMP)	RCR		1.	1				0.00052	0.00125	0.00148	0.00344
R6	RESISTOR(FIXED-COMP)	RCR		1.	1				0.00052	0.00125	0.00148	0.00344
R7	RESISTOR(TRIMMER)	RJ		10.	1				5.88156	6.46734	6.62407	7.73601
R11	RESISTOR(FIXED-COMP)	RCR		10.	1				0.00061	0.00148	0.00177	0.00416
R13	RESISTOR(FIXED-COMP)	RCR		1.	1				0.00052	0.00125	0.00148	0.00344
R14	RESISTOR(FIXED-COMP)	RCR		80.	1				0.00213	0.00577	0.00705	0.01935
R1516	RESISTOR(FIXED-COMP)	RCR		70.	2				0.00356	0.00951	0.01157	0.02979
R17	RESISTOR(FIXED-COMP)	RCR		20.	1				0.00073	0.00180	0.00216	0.00515
R21	RESISTOR(FIXED-COMP)	RCR		40.	1				0.00104	0.00266	0.00320	0.00786
R22	RESISTOR(FIXED-COMP)	RCR		1.	1				0.00052	0.00125	0.00148	0.00344
R23	RESISTOR(FIXED-COMP)	RCR		10.	1				0.00061	0.00148	0.00177	0.00416
R24	RESISTOR(FIXED-COMP)	RCR		1.	1				0.00052	0.00125	0.00148	0.00344
R25	RESISTOR(FIXED-COMP)	RCR		4.	1				0.00055	0.00132	0.00157	0.00367
R26	RESISTOR(FIXED-COMP)	RCR		1.	1				0.00052	0.00125	0.00148	0.00344
R12	RESISTOR(FIXED-COMP)	RCR		1.	1				0.00052	0.00125	0.00148	0.00344
R27	RESISTOR(FIXED-WW)	RE/OG		20.	1				0.19124	0.24822	0.26151	0.33591
R31	RESISTOR(FIXED-COMP)	RCR		1.	1				0.00052	0.00125	0.00148	0.00344
R32	RESISTOR(POWER-FILM)	RNR		2.	1				0.00672	0.00839	0.00877	0.01085
R33	RESISTOR(POWER-FILM)	RNR		1.	1				0.00665	0.00829	0.00866	0.01071
R34	RESISTOR(POWER-FILM)	RNR		6.	1				0.00701	0.00879	0.00919	0.01141
R35	RESISTOR(FIXED-COMP)	RCR		1.	1				0.00057	0.00137	0.00163	0.00379
R36	RESISTOR(FIXED-COMP)	RCR		1.	1				0.00057	0.00137	0.00163	0.00379
R37	RESISTOR(FIXED-COMP)	RCR		1.	1				0.00057	0.00137	0.00163	0.00379

CONTRACT MLS PROGRAM EQUIPMENT BASIC AIRBORNE EQUIP DATE 2/26/76 REV

ASSEMBLY ACTIVE EQUIP SUBASSEMBLY ANGLE REC/PROC BOARD POWER SUPPLY INTERNAL TEMPERATURE RISE 20

ENVIRONMENT/TEMPERATURE CONDITION PAIRS FOLLOW
(F.R.1) AIRBORNE,INHABITED 0 DEGREES C (F.R.2) AIRBORNE,INHABITED 25 DEGREES C (F.R.3) AIRBORNE,INHABITED 30 DEGREES C (F.R.4) AIRBORNE,INHABITED 54 DEGREES C

CKT SYMBL	PART DESCR	PART TYPE	NON-STD PART NO.	PERCT STRESS	QTY	F.R. SOURCE	REV	ERROR CODE	(F.R.1)	(F.R.2)	(F.R.3)	(F.R.4)
R41	RESISTOR(FIXED-COMP)	RCR		13.	1				0.00064	0.00157	0.00188	0.00444
R42	RESISTOR(FIXED-COMP)	RCR		20.	1				0.00073	0.00180	0.00216	0.00515
RV1	RESISTOR(POWER-FILM)	RD	VARISTOR	10.	1				0.89732	0.94263	0.95266	1.00586
C1-C2	CAPACITOR(ALUM. EL.)	CU		70.	2				2.67684	4.67378	5.34712	11.58376
C3	CAPACITOR(TANT. EL.)	CSR		60.	1				0.06190	0.07408	0.07802	0.11171
C4	CAPACITOR(CERAMIC)	CK		50.	1				0.45433	0.48719	0.49404	0.52830
C5	CAPACITOR(DIP. MICA)	CM		2.	1				0.00540	0.01476	0.01804	0.04735
C6	CAPACITOR(CERAMIC)	CK		2.	1				0.08073	0.08657	0.08778	0.09387
C7	CAPACITOR(TANT. EL.)	CSR		5.	1				0.00284	0.00339	0.00357	0.00512
C11	CAPACITOR(TANT. EL.)	CSR		15.	1				0.00104	0.00125	0.00131	0.00188
C1213	CAPACITOR(CERAMIC)	CK		10.	2				0.16738	0.17949	0.18202	0.19464
C14	CAPACITOR(CERAMIC)	CK		20.	1				0.10462	0.11218	0.11376	0.12165
C15	CAPACITOR(TANT. EL.)	CSR		70.	1				0.08998	0.10767	0.11341	0.16238
C16	CAPACITOR(TANT. EL.)	CSR		50.	1				0.04178	0.05000	0.05266	0.07541
C17	CAPACITOR(TANT. EL.)	CSR		60.	1				0.06190	0.07408	0.07802	0.11171
C21	CAPACITOR(ALUM. EL.)	CU		40.	1				0.54052	0.94375	1.07971	2.33892
C22	CAPACITOR(ALUM. EL.)	CU		60.	1				0.97522	1.70274	1.94804	4.21996
C33	CAPACITOR(CERAMIC)	CK		10.	1				0.08369	0.08975	0.09101	0.09732
L1	POWER XFMR/FILTER			0.	1				0.02820	0.03301	0.03452	0.04688
L2	POWER XFMR/FILTER			0.	1				0.02820	0.03301	0.03452	0.04688
L3	POWER XFMR/FILTER			0.	1				0.02820	0.03301	0.03452	0.04688
L4	POWER XFMR/FILTER			0.	1				0.02820	0.03301	0.03452	0.04688
L5	POWER XFMR/FILTER			0.	1				0.02820	0.03301	0.03452	0.04688
L6	POWER XFMR/FILTER			0.	1				0.02820	0.03301	0.03452	0.04688
L7	POWER XFMR/FILTER			0.	1				0.02820	0.03301	0.03452	0.04688
L11	POWER XFMR/FILTER			0.	1				0.02820	0.03301	0.03452	0.04688
T1	POWER XFMR/FILTER			0.	1				0.03452	0.04767	0.05213	0.09416
T2	POWER XFMR/FILTER			0.	1				0.03452	0.04767	0.05213	0.09416
	CONNECTOR			0.	1				0.10565	0.19773	0.22268	0.36583
TOTAL FAILURE RATES FOR THIS LEVEL ARE........									17.92465	23.92792	25.74274	40.75922

CONTRACT MLS PROGRAM EQUIPMENT BASIC AIRBORNE EQUIP DATE 2/26/76 REV

ASSEMBLY ACTIVE EQUIP SUBASSEMBLY ANGLE REC/PROC BOARD SYNTHESIZER INTERNAL TEMPERATURE,RISE 20

ENVIRONMENT/TEMPERATURE CONDITION PAIRS FOLLOW
(F.R.1) AIRBORNE,INHABITED (F.R.2) AIRBORNE,INHABITED (F.R.3) AIRBORNE,INHABITED (F.R.4) AIRBORNE,INHABITED
0 DEGREES C 25 DEGREES C 30 DEGREES C 54 DEGREES C

CKT SYMBL	PART DESCR	PART TYPE	NON-STD PART NO.	PERCT STRESS	QTY	F.R. SOURCE	REV	ERROR CODE	(F.R.1)	(F.R.2)	(F.R.3)	(F.R.4)
U1	MICROELEC. SSI/MSI			0.	1				0.73884	0.97274	1.09375	2.71220
U2	MICROELEC. SSI/MSI			0.	1				0.26112	0.29582	0.31377	0.55390
U3	MICROELEC. SSI/MSI			0.	1				0.45350	0.54957	0.59928	1.26404
U4 U7	MICROELEC. SSI/MSI			0.	2				0.52223	0.59164	0.62755	1.10760
U5	MICROELEC. LINEAR			0.	1				0.46439	0.51092	0.53500	0.85696
U6 U8	MICROELEC. SSI/MSI			0.	2				0.86844	1.04586	1.13765	2.36528
U9	MICROELEC. LINEAR			0.	1				0.62860	0.69939	0.73602	1.22587
U1011	MICROELEC. LINEAR			0.	2				1.76230	1.98834	2.10529	3.66939
U1214	MICROELEC. SSI/MSI			0.	3				1.89470	2.42255	2.69564	6.34911
U15	ROM MEMORY			0.	1				2.63049	6.38348	8.18411	30.08156
U16	MICROELEC. SSI/MSI			0.	1				0.43200	0.45772	0.46673	0.54135
U17	MICROELEC. SSI/MSI			0.	1				0.43200	0.45772	0.46673	0.54135
U18	MICROELEC. LINEAR			0.	1				0.60150	0.66809	0.70255	1.16339
Q1	TRANSISTOR (SI)	NPN		3.	1				0.06448	0.08637	0.09128	0.11843
Q2	TRANSISTOR (SI)	PNP		65.	1				0.22022	0.33018	0.36543	0.70551
Q3	TRANSISTOR (SI)	NPN		35.	1				1.98190	2.61236	2.76941	3.78307
CR1 2	DIODE (SI)	GP		15.	2				0.17995	0.29766	0.32672	0.49971
CR313	DIODE (SI)	GP		1.	11				0.60957	1.07787	1.19589	1.89846
CR14	DIODE(VAR/REC/TUN)			10.	1				2.68772	3.60719	3.81277	4.94604
CR15	DIODE(VAR/REC/TUN)			10.	1				2.68772	3.60719	3.81277	4.94604
	DIODE(MW MIXER)	(SI)		10.	2				18.42584	20.62199	21.10993	24.05401
Q11	TRANSISTOR (SI)	NPN		25.	1				0.15161	0.19881	0.21004	0.27818
Q1213	TRANSISTOR (SI)	NPN		50.	2				0.60927	0.82891	0.88858	1.31961
Q14	TRANSISTOR (SI)	NPN		50.	1				1.01545	1.38152	1.48096	2.19934
CR12	DIODE (ZENER)			15.	1				0.39898	0.48744	0.50676	0.61370
R1	RESISTOR(FIXED-COMP)	RCR		1.	6				0.00311	0.00747	0.00891	0.02065
R2	RESISTOR(FIXED-COMP)	RCR		1.	1				0.00130	0.00311	0.00371	0.00860
R7	RESISTOR(FIXED-COMP)	RCR		1.	1				0.00052	0.00125	0.00148	0.00344
R8	RESISTOR(FIXED-COMP)	RCR		1.	4				0.00207	0.00498	0.00594	0.01377
R11	RESISTOR(FIXED-COMP)	RCR		1.	2				0.00104	0.00249	0.00297	0.00688
R12	RESISTOR(FIXED-COMP)	RCR		3.	15				0.00806	0.01942	0.02316	0.05356
R14	RESISTOR(FIXED-COMP)	RCR		1.	5				0.00259	0.00623	0.00742	0.01721
R16	RESISTOR(FIXED-COMP)	RCR		3.	2				0.00108	0.00259	0.00309	0.00718
R34	RESISTOR(FIXED-COMP)	RCR		3.	2				0.00108	0.00259	0.00309	0.00718
R54	RESISTOR(FIXED-COMP)	RCR		30.	1				0.00087	0.00219	0.00263	0.00636
R56	RESISTOR(FIXED-COMP)	RCR		5.	6				0.00334	0.00808	0.00964	0.02248
R57	RESISTOR(FIXED-COMP)	RCR		30.	1				0.00087	0.00219	0.00263	0.00636
R58	RESISTOR(FIXED-COMP)	RCR		15.	1				0.00067	0.00163	0.00196	0.00463
R59	RESISTOR(FIXED-COMP)	RCR		4.	4				0.00219	0.00528	0.00630	0.01467
R61	RESISTOR(FIXED-COMP)	RCR		3.	1				0.00054	0.00129	0.00154	0.00359
R62	RESISTOR(FIXED-COMP)	RCR		3.	1				0.00054	0.00129	0.00154	0.00359
R64	RESISTOR(FIXED-COMP)	RCR		1.	4				0.00207	0.00498	0.00594	0.01377
R67	RESISTOR(FIXED-COMP)	RCR		1.	2				0.00104	0.00249	0.00297	0.00688
R77	RESISTOR(FIXED-COMP)	RCR		30.	1				0.00087	0.00219	0.00263	0.00636
R30	RESISTOR(TRIMMER)	RJ		1.	1				5.65199	6.15519	6.29722	7.29298
R6M	RESISTOR(FIXED-COMP)	RCR		60.	1				0.00149	0.00392	0.00475	0.01201

CONTRACT MLS PROGRAM EQUIPMENT BASIC AIRBORNE EQUIP DATE 2/26/76 REV

ASSEMBLY ACTIVE EQUIP SUBASSEMBLY ANGLE REC/PROC BOARD SYNTHESIZER INTERNAL TEMPERATURE RISE 20

ENVIRONMENT/TEMPERATURE CONDITION PAIRS FOLLOW

(F.R.1) AIRBORNE,INHABITED 0 DEGREES C (F.R.2) AIRBORNE,INHABITED 25 DEGREES C (F.R.3) AIRBORNE,INHABITED 30 DEGREES C (F.R.4) AIRBORNE,INHABITED 54 DEGREES C

CKT SYMBL	PART DESCR	PART TYPE	NON-STD PART NO.	PERCT STRESS	QTY	F.R. SOURCE	REV	ERROR CODE	(F.R.1)	(F.R.2)	(F.R.3)	(F.R.4)
R69	RESISTOR(FIXED-COMP)	RCR		1.	3				0.00156	0.00374	0.00445	0.01033
R70	RESISTOR(FIXED-COMP)	RCR		1.	1				0.00052	0.00125	0.00148	0.00344
R7172	RESISTOR(FIXED-COMP)	RCR		1.	4				0.00207	0.00498	0.00594	0.01377
R73	RESISTOR(FIXED-COMP)	RCR		1.	1				0.00052	0.00125	0.00148	0.00344
R74	RESISTOR(FIXED-COMP)	RCR		60.	1				0.00149	0.00392	0.00475	0.01201
R7576	RESISTOR(FIXED-COMP)	RCR		60.	2				0.00298	0.00783	0.00950	0.02402
R94	RESISTOR(FIXED-COMP)	RCR		50.	1				0.00125	0.00322	0.00390	0.00972
R81	RESISTOR(FIXED-COMP)	RCR		60.	2				0.00298	0.00783	0.00950	0.02402
R82	RESISTOR(FIXED-COMP)	RCR		10.	1				0.00061	0.00148	0.00177	0.00416
	THERMISTOR	RTH		20.	1				1.60000	1.60000	1.60000	1.60000
C1	CAPACITOR(CERAMIC)	CK		25.	10				1.17346	1.24954	1.26534	1.34398
C6	CAPACITOR(CERAMIC)	CK		35.	3				0.57710	0.61451	0.62228	0.66096
C14	CAPACITOR(CERAMIC)	CK		15.	2				0.16724	0.17809	0.18034	0.19155
C15	CAPACITOR(CERAMIC)	CK		20.	2				0.19271	0.20520	0.20780	0.22071
C21	CAPACITOR(CERAMIC)	CK		40.	1				0.25052	0.26676	0.27014	0.28693
C22	CAPACITOR(CERAMIC)	CK		10.	10				0.77084	0.82081	0.83119	0.88285
C33	CAPACITOR(CERAMIC)	CK		30.	4				0.59465	0.63320	0.64120	0.68106
C8	CAPACITOR(TANT. EL.)	CSR		33.	1				0.00884	0.01058	0.01114	0.01595
C1820	CAPACITOR(TANT. EL.)	CSR		33.	2				0.01768	0.02115	0.02228	0.03190
C29	CAPACITOR(TANT. EL.)	CSR		33.	1				0.00884	0.01058	0.01114	0.01595
C37	CAPACITOR(CERAMIC)	CK		5.	3				0.21449	0.22755	0.23025	0.24369
C3843	CAPACITOR(CERAMIC)	CK		5.	6				0.42897	0.45509	0.46050	0.48738
C44	CAPACITOR(VARIABLE)	PC		5.	1				0.03241	0.06914	0.08045	0.15649
C4546	CAPACITOR(VAR. CER.)	CV		1.	2				0.11882	0.15565	0.16888	0.30513
C4748	CAPACITOR(VAR. CER.)	CV		1.	2				0.11882	0.15565	0.16888	0.30513
C50	CAPACITOR(CERAMIC)	CK		10.	12				0.92501	0.98497	0.99743	1.05942
C53	CAPACITOR(VAR. CER.)	CV		10.	4				0.28594	0.37459	0.40642	0.73434
C52	CAPACITOR(DIP. MICA)	CM		10.	1				0.00549	0.01499	0.01832	0.04209
C57	CAPACITOR(VARIABLE)	PC		5.	2				0.06483	0.13828	0.16091	0.33298
C60	CAPACITOR(CERAMIC)	CK		5.	3				0.24323	0.26082	0.26449	0.28283
C65	CAPACITOR(CERAMIC)	CK		1.	2				0.16141	0.17309	0.17552	0.18769
	RF TRANSFORMER/COIL			0.	10				0.42304	0.49510	0.51782	0.70321
	CONNECTOR			0.	2				0.86356	1.41953	1.56563	2.50810
	CONNECTOR			0.	1				0.11804	0.22356	0.25222	0.43977

TOTAL FAILURE RATES FOR THIS LEVEL ARE........ 55.78979 69.21585 73.80708 119.15617

CONTRACT MLS PROGRAM EQUIPMENT BASIC AIRBORNE EQUIP DATE 2/26/76 REV

ASSEMBLY ACTIVE EQUIP SUBASSEMBLY ANGLE REC/PROC BOARD FRONT END INTERNAL TEMPERATURE RISE 20

ENVIRONMENT/TEMPERATURE CONDITION PAIRS FOLLOW
(F.R.1) AIRBORNE,INHABITED 0 DEGREES C
(F.R.2) AIRBORNE,INHABITED 25 DEGREES C
(F.R.3) AIRBORNE,INHABITED 30 DEGREES C
(F.R.4) AIRBORNE,INHABITED 54 DEGREES C

CKT SYMBL	PART DESCR	PART TYPE	NON-STD PART NO.	PERCT STRESS	QTY	F.R. SOURCE	REV	ERROR CODE	(F.R.1)	(F.R.2)	(F.R.3)	(F.R.4)
	DIODE(MW MIXER)	(SI)		10.	2				18.42584	20.62199	21.10993	24.05401

TOTAL FAILURE RATES FOR THIS LEVEL ARE........ 18.42583 20.62199 21.10993 24.05400

CONTRACT MLS PROGRAM EQUIPMENT BASIC AIRBORNE EQUIP DATE 2/26/76 REV

ASSEMBLY ACTIVE EQUIP SUBASSEMBLY ANGLE REC/PROC BOARD R.F. MODULE INTERNAL TEMPERATURE RISE 20

ENVIRONMENT/TEMPERATURE CONDITION PAIRS FOLLOW
(F.R.1) AIRBORNE,INHABITED 0 DEGREES C (F.R.2) AIRBORNE,INHABITED 25 DEGREES C (F.R.3) AIRBORNE,INHABITED 30 DEGREES C (F.R.4) AIRBORNE,INHABITED 54 DEGREES C

CKT SYMBL	PART DESCR	PART TYPE	NON-STD PART NO.	PERCT STRESS	QTY	F.R. SOURCE	REV	ERROR CODE	(F.R.1)	(F.R.2)	(F.R.3)	(F.R.4)
U11	QUARTZ CRYSTAL		FILTER XTAL	0.	6				1.20000	1.20000	1.20000	1.20000
Y1	QUARTZ CRYSTAL			0.	1				0.20000	0.20000	0.20000	0.20000
U1	MICROELEC. LINEAR			0.	1				0.60150	0.66809	0.70255	1.16339
A1-A6	MICROELEC. LINEAR			0.	6				1.52293	1.64367	1.70613	2.54157
U3	MICROELEC. LINEAR			0.	1				0.48118	0.53006	0.55535	0.89356
U4	MICROELEC. SSI/MSI			0.	1				0.26025	0.27031	0.27383	0.30303
U5	MICROELEC. SSI/MSI			0.	1				0.43200	0.45772	0.46673	0.54135
U2	MICROELEC. LINEAR			0.	1				0.66755	0.74450	0.78431	1.31673
U11	MICROELEC. LINEAR			0.	1				0.48118	0.53006	0.55535	0.89356
A7	MICROELEC. LINEAR			0.	1				0.49751	0.54870	0.57518	0.92941
A?	MICROELEC. LINEAR			0.	1				0.48118	0.53006	0.55535	0.89356
U6	MICROELEC. SSI/MSI			0.	1				0.26025	0.27031	0.27383	0.30303
Q1	TRANSISTOR (SI)	NPN		10.	1				0.26952	0.35705	0.37696	0.48943
Q2	FET			27.	1				1.21693	1.59750	1.68666	2.22573
Q3	TRANSISTOR (SI)	NPN		9.	1				0.11554	0.15328	0.16184	0.21004
CR1	DIODE (SI)	GP		9.	1				0.07368	0.12514	0.13792	0.21374
U2	DIODE(MW MIXER)	(SI)		5.	4				35.81063	40.08663	41.00759	46.29957
Q4-Q7	TRANSISTOR (SI)	NPN		2.	4				0.33906	0.45499	0.48100	0.62427
Q13	TRANSISTOR (SI)	NPN		4.	1				0.14075	0.18819	0.19886	0.25705
CR2-4	DIODE (ZENER)			15.	2				0.79796	0.97488	1.01352	1.22741
CR3	DIODE (SI)	GP		5.	2				0.12815	0.22192	0.24537	0.38453
R1 9	RESISTOR(FIXED-COMP)	RCR		3.	2				0.00108	0.00259	0.00309	0.00718
R2	RESISTOR(FIXED-COMP)	RCR		12.	1				0.00063	0.00154	0.00184	0.00434
R3	RESISTOR(FIXED-COMP)	RCR		1.	1				0.00052	0.00125	0.00148	0.00344
R4	RESISTOR(FIXED-COMP)	RCR		2.	6				0.00317	0.00762	0.00908	0.02109
R5	RESISTOR(FIXED-COMP)	RCR		5.	1				0.00056	0.00135	0.00161	0.00375
R6	RESISTOR(FIXED-COMP)	RCR		33.	1				0.00092	0.00232	0.00279	0.00678
R7	RESISTOR(FIXED-COMP)	RCR		1.	10				0.00519	0.01246	0.01484	0.03442
R8	RESISTOR(FIXED-COMP)	RCR		5.	1				0.00056	0.00135	0.00161	0.00375
R10	RESISTOR(FIXED-COMP)	RCR		1.	1				0.00052	0.00125	0.00148	0.00344
R11	RESISTOR(FIXED-COMP)	RCR		7.	1				0.00058	0.00140	0.00167	0.00391
R12	RESISTOR(FIXED-COMP)	RCR		19.	1				0.00072	0.00177	0.00212	0.00504
R13	RESISTOR(FIXED-COMP)	RCR		10.	1				0.00061	0.00148	0.00177	0.00416
R1418	RESISTOR(FIXED-COMP)	RCR		1.	2				0.00104	0.00249	0.00297	0.00688
R1519	RESISTOR(TRIMMER)	RJ		1.	3				18.65158	20.31212	20.78081	24.03350
R1617	RESISTOR(FIXED-COMP)	RCR		1.	12				0.00622	0.01495	0.01781	0.04130
R2021	RESISTOR(FIXED-COMP)	RCR		1.	12				0.00622	0.01495	0.01781	0.04130
R22	RESISTOR(FIXED-COMP)	RCR		1.	1				0.00052	0.00125	0.00148	0.00344
R23	RESISTOR(FIXED-COMP)	RCR		33.	1				0.00092	0.00232	0.00279	0.00678
R24	RESISTOR(FIXED-COMP)	RCR		1.	1				0.00052	0.00125	0.00148	0.00344
C1028	CAPACITOR(CERAMIC)	CK		2.	7				0.56509	0.60596	0.61449	0.65709
C109	CAPACITOR(CERAMIC)	CK		20.	3				0.28906	0.30780	0.31170	0.33107
C110	CAPACITOR(VAR. CER.)	CV		10.	2				0.14297	0.18730	0.20321	0.36717
C111	CAPACITOR(DIP. MICA)	CM		1.	7				0.03781	0.10330	0.12629	0.33144
C112	CAPACITOR(CERAMIC)	CK		10.	6				0.50215	0.53847	0.54605	0.58391
C202	CAPACITOR(CERAMIC)	CY		1.	4				0.29733	0.31661	0.32061	0.34054

CONTRACT MLS PROGRAM EQUIPMENT BASIC AIRBORNE EQUIP DATE 2/26/76 REV

ASSEMBLY ACTIVE EQUIP SUBASSEMBLY ANGLE REC/PROC BOARD R.F. MODULE INTERNAL TEMPERATURE RISE 20

ENVIRONMENT/TEMPERATURE CONDITION PAIRS FOLLOW
(F.R.1) AIRBORNE,INHABITED 0 DEGREES C (F.R.2) AIRBORNE,INHABITED 25 DEGREES C (F.R.3) AIRBORNE,INHABITED 30 DEGREES C (F.R.4) AIRBORNE,INHABITED 54 DEGREES C

CKT SYMBL	PART DESCR	PART TYPE	NON-STD PART NO.	PERCT STRESS	QTY	F.R. SOURCE	REV	ERROR CODE	(F.R.1)	(F.R.2)	(F.R.3)	(F.R.4)
C215	CAPACITOR(CERAMIC)	CK		11.	1				0.08468	0.09081	0.09208	0.09847
C209	CAPACITOR(CERAMIC)	CK		15.	3				0.25087	0.26713	0.27051	0.28732
C231	CAPACITOR(CERAMIC)	CK		0.	1				0.07433	0.07915	0.08015	0.08513
C224	CAPACITOR(CERAMIC)	CK		30.	3				0.44599	0.47490	0.48090	0.51079
C227	CAPACITOR(CERAMIC)	CK		10.	1				0.07708	0.08208	0.08312	0.08829
C204	CAPACITOR(TANT. EL.)	CSR		10.	9				0.02587	0.03095	0.03260	0.04668
C134	CAPACITOR(CERAMIC)	CK		9.	3				0.24865	0.26663	0.27038	0.28913
C211	CAPACITOR(CERAMIC)	CK		9.	2				0.15268	0.16257	0.16463	0.17486
C531	CAPACITOR(CERAMIC)	CK		24.	2				0.24405	0.26170	0.26538	0.28378
C610	CAPACITOR(CERAMIC)	CK		12.	2				0.15144	0.16066	0.16257	0.17206
C712	CAPACITOR(CERAMIC)	CK		1.	2				0.14234	0.15100	0.15280	0.16172
C813	CAPACITOR(VARIABLE)	PC		2.	2				0.06462	0.13783	0.16038	0.33190
C915	CAPACITOR(CERAMIC)	CK		3.	2				0.14247	0.15115	0.15295	0.16187
C14	CAPACITOR(CERAMIC)	CK		6.	1				0.07493	0.07978	0.08079	0.08581
C1623	CAPACITOR(VARIABLE)	PC		5.	2				0.06483	0.13828	0.16091	0.33298
C17	CAPACITOR(CERAMIC)	CK		24.	1				0.12202	0.13085	0.13269	0.14189
C1820	CAPACITOR(CERAMIC)	CK		24.	2				0.24405	0.26170	0.26538	0.28378
C19	CAPACITOR(CERAMIC)	CK		5.	1				0.08108	0.08694	0.08816	0.09428
C21	CAPACITOR(CERAMIC)	CK		12.	1				0.07572	0.08033	0.08129	0.08603
C22	CAPACITOR(CERAMIC)	CK		24.	1				0.11239	0.11967	0.12119	0.12872
C24	CAPACITOR(CERAMIC)	CK		15.	1				0.08362	0.08904	0.09017	0.09577
C25	CAPACITOR(CERAMIC)	CK		12.	1				0.07572	0.08033	0.08129	0.08603
C2627	CAPACITOR(CERAMIC)	CK		24.	2				0.24405	0.26170	0.26538	0.28378
C2829	CAPACITOR(CERAMIC)	CK		12.	2				0.17174	0.18416	0.18675	0.19970
C30	CAPACITOR(CERAMIC)	CK		24.	1				0.12202	0.13085	0.13269	0.14189
J1	CONNECTOR			0.	2				0.56827	0.93455	1.03076	1.65102
J2	CONNECTOR			0.	1				0.28414	0.46727	0.51538	0.82551
	CONNECTOR			0.	1				0.07326	0.13874	0.15653	0.27292
	CONNECTOR			0.	3				0.86356	1.41953	1.56563	2.50810
L1	RF TRANSFORMER/COIL			0.	1				0.04230	0.04951	0.05178	0.07032
L2-5	RF TRANSFORMER/COIL			0.	4				0.16922	0.19804	0.20713	0.28129
L6-8	RF TRANSFORMER/COIL			0.	3				0.12691	0.14853	0.15535	0.21096
L9	RF TRANSFORMER/COIL			0.	1				0.04230	0.04951	0.05178	0.07032
U2	RF TRANSFORMER/COIL			0.	2				0.08461	0.09902	0.10356	0.14064
L101	RF TRANSFORMER/COIL			0.	8				0.37313	0.43987	0.46655	0.78350
U10	RF TRANSFORMER/COIL			0.	1				0.04230	0.04951	0.05178	0.07032

TOTAL FAILURE RATES FOR THIS LEVEL ARE........ 72.74096 82.15200 84.56007 101.49771

CONTRACT MLS PROGRAM EQUIPMENT BASIC AIRBORNE EQUIP DATE 2/26/76 REV

ASSEMBLY ACTIVE EQUIP SUBASSEMBLY ANGLE REC/PROC BOARD MAIN FRAME INTERNAL TEMPERATURE RISE 20

ENVIRONMENT/TEMPERATURE CONDITION PAIRS FOLLOW
(F.R.1) AIRBORNE,INHABITED (F.R.2) AIRBORNE,INHABITED (F.R.3) AIRBORNE,INHABITED (F.R.4) AIRBORNE,INHABITED
0 DEGREES C 25 DEGREES C 30 DEGREES C 54 DEGREES C

CKT SYMBL	PART DESCR	PART TYPE	NON-STD PART NO.	PERCT STRESS	QTY	F.R. SOURCE	REV	ERROR CODE	(F.R.1)	(F.R.2)	(F.R.3)	(F.R.4)
	CONNECTOR			0.	1				0.43178	0.70977	0.78281	1.25405
	CONNECTOR			0.	1				0.08115	0.15368	0.17338	0.30231
	CONNECTOR			0.	1				0.38267	0.72472	0.81764	1.42563
TOTAL FAILURE RATES FOR THIS LEVEL ARE........									0.89559	1.58816	1.77383	2.98198

CONTRACT MLS PROGRAM . EQUIPMENT BASIC AIRBORNE EQUIP DATE 2/26/76 REV

ASSEMBLY ACTIVE EQUIP SUBASSEMBLY ANTENNA SUBSYST BOARD INTERNAL TEMPERATURE RISE 0

ENVIRONMENT/TEMPERATURE CONDITION PAIRS FOLLOW

(F.R.1) AIRBORNE,INHABITED 0 DEGREES C | (F.R.2) AIRBORNE,INHABITED 25 DEGREES C | (F.R.3) AIRBORNE,INHABITED 30 DEGREES C | (F.R.4) AIRBORNE,INHABITED 54 DEGREES C

CKT SYMBL	PART DESCR	PART TYPE	NON-STD PART NO.	PERCT STRESS	QTY	F.R. SOURCE	REV	ERROR CODE	(F.R.1)	(F.R.2)	(F.R.3)	(F.R.4)
	INSERTED COMPONENT		DIODE SWITCH	0.	1				5.60200	5.60200	5.60200	5.60200
	CONNECTOR			0.	16				4.55376	7.64209	8.44574	13.54487
	TOTAL FAILURE RATES FOR THIS LEVEL ARE........								10.15575	13.24408	14.04774	19.14686

CONTRACT MLS PROGRAM EQUIPMENT BASIC AIRBORNE EQUIP DATE 2/26/76 REV

ASSEMBLY ACTIVE EQUIP SUBASSEMBLY CONTROL PANEL BOARD INTERNAL TEMPERATURE RISE 20

ENVIRONMENT/TEMPERATURE CONDITION PAIRS FOLLOW
(F.R.1) AIRBORNE,INHABITED 0 DEGREES C (F.R.2) AIRBORNE,INHABITED 25 DEGREES C (F.R.3) AIRBORNE,INHABITED 30 DEGREES C (F.R.4) AIRBORNE,INHABITED 54 DEGREES C

CKT SYMBOL	PART DESCR	PART TYPE	NON-STD PART NO.	PERCT STRESS	QTY	F.R. SOURCE	REV	ERROR CODE	(F.R.1)	(F.R.2)	(F.R.3)	(F.R.4)
U1 U4	ROM MEMORY			0.	4				6.16135	15.14648	19.45741	71.88258
U5 U6	ROM MEMORY			0.	2				1.27884	3.22623	4.16056	15.52290
U7 U8	MICROELEC. SSI/MSI			0.	2				1.59461	1.75268	1.80804	2.26667
U9U10	MICROELEC. SSI/MSI			0.	2				1.46596	1.60159	1.64909	2.04262
U11-3	MICROELEC. SSI/MSI			0.	3				0.78074	0.81092	0.82150	0.90908
U14	MICROELEC. SSI/MSI			0.	1				0.30171	0.31495	0.31959	0.35800
U15	MICROELEC. SSI/MSI			0.	1				0.26025	0.27031	0.27383	0.30303
U16	MICROELEC. LINEAR			0.	1				0.58757	0.65204	0.68539	1.13150
U17	MICROELEC. LINEAR			0.	1				0.52891	0.58464	0.61347	0.99907
	TRANSISTOR (SI)	PNP		3.	1				0.14226	0.20216	0.21573	0.29012
	TRANSISTOR (SI)	PNP		60.	1				0.56896	0.56896	0.56896	0.56896
	DIODE (GE)	GP		1.	1				0.05879	0.15619	0.18795	0.47438
	DIODE (SI)	GP		1.	1				0.05542	0.09799	0.10872	0.17259
	RESISTOR(POT-COMP)	RV		40.	1				11.00037	14.22634	15.23927	23.72709
R1	RESISTOR(FIXED-COMP)	RCR		3.	1				0.00054	0.00129	0.00154	0.00359
R2	RESISTOR(FIXED-COMP)	RCR		10.	1				0.00061	0.00148	0.00177	0.00416
R3	RESISTOR(FIXED-COMP)	RCR		1.	1				0.00057	0.00137	0.00163	0.00379
R4	RESISTOR(FIXED-COMP)	RCR		1.	1				0.00057	0.00137	0.00163	0.00379
R6	RESISTOR(FIXED-COMP)	RCR		3.	1				0.00054	0.00129	0.00154	0.00359
R7	RESISTOR(FIXED-COMP)	RCR		3.	1				0.00054	0.00129	0.00154	0.00359
R8	RESISTOR(FIXED-COMP)	RCR		3.	1				0.00054	0.00129	0.00154	0.00359
R9	RESISTOR(FIXED-COMP)	RCR		8.	1				0.00059	0.00143	0.00170	0.00399
R10	RESISTOR(POWER-FILM)	RNR		4.	1				0.00686	0.00858	0.00898	0.01113
R11	RESISTOR(POWER-FILM)	RNR		3.	1				0.00679	0.00848	0.00887	0.01098
R12	RESISTOR(FIXED-COMP)	RCR		1.	1				0.00083	0.00199	0.00237	0.00551
R13	RESISTOR(FIXED-COMP)	RCR		1.	1				0.00052	0.00125	0.00148	0.00344
R14	RESISTOR(FIXED-COMP)	RCR		7.	1				0.00058	0.00140	0.00167	0.00391
	SWITCH, TOGGLE/PB			0.	3				1.26000	1.26000	1.26000	1.26000
	SWITCH, ROTARY-MP			0.	9				98.49598	98.49598	98.49598	98.49598
	CONNECTOR			0.	1				0.26981	0.51098	0.57650	1.00518
	CONNECTOR			0.	1				0.24516	0.46630	0.52383	0.91335
	LAMP, INCANDESCENT			0.	16				16.00000	16.00000	16.00000	16.00000

TOTAL FAILURE RATES FOR THIS LEVEL ARE........ 141.07669 156.37515 163.00198 238.38790

CONTRACT MLS PROGRAM   EQUIPMENT BASIC AIRBORNE EQUIP   DATE 2/26/76   REV

ASSEMBLY ACTIVE EQUIP   SUBASSEMBLY AUX DATA DISPLAY   BOARD   INTERNAL TEMPERATURE RISE 35

ENVIRONMENT/TEMPERATURE CONDITION PAIRS FOLLOW
(F.R.1) AIRBORNE,INHABITED 0 DEGREES C   (F.R.2) AIRBORNE,INHABITED 25 DEGREES C   (F.R.3) AIRBORNE,INHABITED 30 DEGREES C   (F.R.4) AIRBORNE,INHABITED 54 DEGREES C

CKT SYMBL	PART DESCR	PART TYPE	NON-STD PART NO.	PERCT STRESS	QTY	F.R. SOURCE	REV	ERROR CODE	(F.R.1)	(F.R.2)	(F.R.3)	(F.R.4)
U1	MICROELEC. SSI/MSI			0.	1				0.47384	0.52595	0.54333	0.60013
U2	MICROELEC. SSI/MSI			0.	1				0.39878	0.43695	0.44968	0.54991
U3	MICROELEC. SSI/MSI			0.	1				0.72867	0.84087	0.87830	1.17292
U4	MICROELEC. SSI/MSI			0.	1				0.26502	0.28316	0.28921	0.33685
U5-12	MICROELEC. SSI/MSI			0.	8				6.12100	7.09934	7.42569	9.99452
U4344	MICROELEC. SSI/MSI			0.	2				1.53025	1.77484	1.85642	2.49863
U4748	MICROELEC. SSI/MSI			0.	2				1.53025	1.77484	1.85642	2.49863
U13	MICROELEC. SSI/MSI			0.	1				0.30799	0.33186	0.33982	0.40252
U1520	MICROELEC. SSI/MSI			0.	6				1.95686	2.11587	2.16891	2.58643
U22	MICROELEC. SSI/MSI			0.	1				0.26502	0.28316	0.28921	0.33685
U23	MICROELEC. SSI/MSI			0.	1				0.34276	0.37177	0.38145	0.45762
U2427	ROM MEMORY			0.	4				8.11040	25.31365	33.19786	123.82170
U28	MICROELEC. SSI/MSI			0.	1				0.23830	0.25323	0.25821	0.29742
U2930	RAM MEMORY			0.	2				2.46956	7.94159	10.44941	39.27516
U33	MICROELEC. SSI/MSI			0.	1				0.39878	0.43695	0.44968	0.54991
U37	ROM MEMORY			0.	1				2.23036	6.96125	9.12941	34.05096
U3940	ROM MEMORY			0.	2				4.05520	12.65682	16.59893	61.91085
U410	MICROELEC. SSI/MSI			0.	1				0.39878	0.43695	0.44968	0.54991
U35	MICROELEC. SSI/MSI			0.	1				0.58380	0.65952	0.68477	0.87358
U36	MICROELEC. SSI/MSI			0.	1				0.61596	0.69926	0.72705	0.94578
U450	TRANSISTOR (SI)	NPN		53.	1				0.11240	0.16221	0.17699	0.29704
U488	TRANSISTOR (SI)	NPN		53.	1				0.11240	0.16221	0.17699	0.29704
	TRANSISTOR (SI)	NPN		5.	184				19.66854	25.91276	27.35018	35.63864
U41	MICROELEC. LINEAR			0.	1				0.76156	1.01047	1.12990	2.58225
U42	MICROELEC. LINEAR			0.	1				0.62670	0.81753	0.90908	2.02249
U420	MICROELEC. SSI/MSI			0.	1				0.26502	0.28316	0.28921	0.33685
U430	MICROELEC. SSI/MSI			0.	1				0.26502	0.28316	0.28921	0.33685
	RESISTOR(FIXED-COMP)	RCR		4.	13				0.01207	0.02912	0.03472	0.08028
	RESISTOR(FIXED-COMP)	RCR		7.	14				0.01375	0.03333	0.03978	0.09307
	CAPACITOR(CERAMIC)	CK		25.	5				0.66429	0.71234	0.72236	0.77244
	LAMP, INCANDESCENT			0.	115				115.00001	115.00001	115.00001	115.00001
	CONNECTOR			0.	12				1.79619	3.28650	3.68894	6.32114
	CONNECTOR			0.	7				0.67632	1.23746	1.38900	2.38010
	CONNECTOR			0.	1				0.39886	0.72979	0.81916	1.40366
	CONNECTOR			0.	1				0.39886	0.72979	0.81916	1.40366
	SWITCH, TOGGLE/PB			0.	1				0.21000	0.21000	0.21000	0.21000
TOTAL FAILURE RATES FOR THIS LEVEL ARE........									174.00338	221.79745	241.46798	452.97570

CONTRACT MLS PROGRAM EQUIPMENT SMALL COMM AIRB EQ. DATE 2/26/76 REV

ASSEMBLY ACTIVE EQUIP SUBASSEMBLY ANGLE REC/PROC BOARD DIGITAL PROC INTERNAL TEMPERATURE RISE 20

ENVIRONMENT/TEMPERATURE CONDITION PAIRS FOLLOW
(F.R.1) AIRBORNE,INHABITED 0 DEGREES C (F.R.2) AIRBORNE,INHABITED 25 DEGREES C (F.R.3) AIRBORNE,INHABITED 30 DEGREES C (F.R.4) AIRBORNE,INHABITED 54 DEGREES C

CKT SYMBL	PART DESCR	PART TYPE	NON-STD PART NO.	PERCT STRESS	QTY	F.R. SOURCE	REV	ERROR CODE	(F.R.1)	(F.R.2)	(F.R.3)	(F.R.4)
	MICROELEC. LSI			0.	1	6			25.00000	25.00000	25.00000	25.00000
	RAM MEMORY			0.	2				7.36796	9.65762	10.42137	16.43325
	ROM MEMORY			0.	3				26.58851	34.17202	36.70162	56.61365
	MICROELEC. SSI/MSI			0.	1				1.07505	1.16763	1.20006	1.46869
	MICROELEC. SSI/MSI			0.	1				1.43042	1.56454	1.61152	2.00068
	MICROELEC. SSI/MSI			0.	3				2.02505	2.14323	2.18462	2.52751
	MICROELEC. SSI/MSI			0.	1				0.70675	0.74963	0.76465	0.88005
	MICROELEC. SSI/MSI			0.	1				1.11868	1.21823	1.25310	1.54194
	MICROELEC. SSI/MSI			0.	4				2.70007	2.85764	2.91283	3.37001
	RAM MEMORY			0.	4				7.09966	17.97769	23.19681	56.66644
	MICROELEC. SSI/MSI			0.	2				1.78410	1.91568	1.96177	2.34357
	MICROELEC. SSI/MSI			0.	3				1.86596	1.96757	2.00316	2.29797
	MICROELEC. SSI/MSI			0.	1				0.89205	0.95784	0.98089	1.17175
	MICROELEC. LINEAR			0.	1				0.96239	1.06895	1.12408	1.88142
	MICROELEC. SSI/MSI			0.	1				1.13946	1.24242	1.27848	1.57720
	MICROELEC. SSI/MSI			0.	1				0.41639	0.43249	0.43813	0.48454
	MICROELEC. SSI/MSI			0.	1				0.41639	0.43249	0.43813	0.48454
	MICROELEC. SSI/MSI			0.	1				0.41639	0.43249	0.43813	0.48454
	CAPACITOR(TANT. EL.) CSR			30.	1				0.00805	0.00963	0.01014	0.01452
	CONNECTOR			0.	1				0.30936	0.58589	0.66101	1.15292
	QUARTZ CRYSTAL			0.	1				0.20000	0.20000	0.20000	0.20000

TOTAL FAILURE RATES FOR THIS LEVEL ARE........ 83.52258 105.75352 114.78036 208.51456

CONTRACT MLS PROGRAM EQUIPMENT SMALL COMM AIRB EQ. DATE 2/26/76 REV

ASSEMBLY ACTIVE EQUIP SUBASSEMBLY ANGLE REC/PROC BOARD PROCESSOR I/O INTERNAL TEMPERATURE RISE 20

ENVIRONMENT/TEMPERATURE CONDITION PAIRS FOLLOW
(F.R.1) AIRBORNE,INHABITED 0 DEGREES C (F.R.2) AIRBORNE,INHABITED 25 DEGREES C (F.R.3) AIRBORNE,INHABITED 30 DEGREES C (F.R.4) AIRBORNE,INHABITED 54 DEGREES C

CKT SYMBL	PART DESCR	PART TYPE	NON-STD PART NO.	PERCT STRESS	QTY	F.R. SOURCE	REV	ERROR CODE	(F.R.1)	(F.R.2)	(F.R.3)	(F.R.4)
U32	ROM MEMORY			0.	1				2.46454	6.05859	7.78296	28.75303
U31	ROM MEMORY			0.	1				1.02308	2.58098	3.37145	12.41[illegible]
U44	MICROELEC. LINEAR			0.	5				7.89834	8.95647	9.50421	16.[illegible]
U45	MICROELEC. LINEAR			0.	1				0.96239	1.06895	1.12408	1.66142
U43	MICROELEC. LINEAR			0.	4				4.66353	5.21952	5.50717	9.35437
U39	MICROELEC. SSI/MSI			0.	4				3.56819	3.83136	3.92354	4.68213
U11	MICROELEC. SSI/MSI			0.	1				0.70675	0.74963	0.76465	0.88915
U40	MICROELEC. SSI/MSI			0.	1				0.89205	0.95786	0.98089	1.1[illegible]
U48	MICROELEC. SSI/MSI			0.	1				0.58182	0.61175	0.62224	0.71[illegible]
U26	MICROELEC. SSI/MSI			0.	5				5.26044	5.70544	5.86131	7.15249
U24	RAM MEMORY			0.	1				1.77491	4.49442	5.79920	21.66661
U21	MICROELEC. SSI/MSI			0.	1				1.07505	1.16763	1.20006	1.46[illegible]
U8	MICROELEC. SSI/MSI			0.	2				0.96547	1.00784	1.02268	1.14[illegible]60
U9	MICROELEC. SSI/MSI			0.	1				0.41639	0.43249	0.43813	0.4[illegible]
U10	MICROELEC. SSI/MSI			0.	1				0.96869	1.04521	1.07201	1.29464
U12	MICROELEC. SSI/MSI			0.	1				0.41639	0.43249	0.43813	0.4[illegible]
U14	MICROELEC. SSI/MSI			0.	1				0.00000	0.00000	0.00000	0.00000
U15	MICROELEC. LINEAR			0.	1				0.96239	1.06895	1.12408	1.86142
U19	MICROELEC. SSI/MSI			0.	1				0.48273	0.50392	0.51134	0.572[illegible]
U13	MICROELEC. SSI/MSI			0.	1				0.62199	0.65586	0.66772	0.76599
	TRANSISTOR (GE)	NPN		25.	2				0.78662	1.49653	1.71936	4.3[illegible]11
	DIODE (SI)	GP		10.	4				0.30493	0.51551	0.54777	0.87764
	RESISTOR(FIXED-COMP)	RCR		2.	12				0.00634	0.01574	0.01817	0.04219
	RESISTOR(FIXED-COMP)	RCR		20.	4				0.00291	0.00721	0.00764	0.0205[illegible]
	RESISTOR(FIXED-COMP)	RCR		3.	10				0.00538	0.01295	0.01544	0.03591
	RESISTOR(FIXED-COMP)	RCR		2.	4				0.00211	0.00508	0.00606	0.0140[illegible]
	RESISTOR(FIXED-COMP)	RCR		33.	2				0.00184	0.00464	0.0055[illegible]	0.01[illegible]6
	RESISTOR(FIXED-COMP)	RCR		10.	2				0.00122	0.00297	0.00354	0.00[illegible]
	RESISTOR(FIXED-COMP)	RCR		15.	2				0.00133	0.00327	0.00391	0.0097[illegible]
	RESISTOR(POWER-FILM)	RNR		1.	2				0.01379	0.01658	0.01733	0.02142
U30	RESISTOR(FIXED-COMP)	RCR		1.	14				0.00726	0.01744	0.02078	0.04[illegible]
	CONNECTOR			0.	1				0.25732	0.48733	0.54981	0.9[illegible]

TOTAL FAILURE RATES FOR THIS LEVEL ARE........ 37.09559 49.12817 54.70913 11[illegible]

CONTRACT MLS PROGRAM EQUIPMENT SMALL COMM AIRR FQ. DATE 2/26/76 REV

ASSEMBLY ACTIVE EQUIP SUBASSEMBLY ANGLE REC/PROC BOARD POWER SUPPLY INTERNAL TEMPERATURE RISE 20

ENVIRONMENT/TEMPERATURE CONDITION PAIRS FOLLOW
(F.R.1) AIRBORNE,INHABITED 0 DEGREES C (F.R.2) AIRBORNE,INHABITED 25 DEGREES C (F.R.3) AIRBORNE,INHABITED 30 DEGREES C (F.R.4) AIRBORNE,INHABITED 54 DEGREES C

CKT SYMBL	PART DESCR	PART TYPE	NON-STD PART NO.	PERCT STRESS	QTY	F.R. SOURCE	REV	ERROR CODE	(F.R.1)	(F.R.2)	(F.R.3)	(F.R.4)
U1	MICROELEC. LINEAR			0.	1				0.84626	0.93542	0.98155	1.5[illegible]
U2	MICROELEC. LINEAR			0.	1				0.68677	0.75352	0.78805	1.24[illegible]
Q1	TRANSISTOR (SI)	PNP		30.	1				0.51296	0.69373	0.73790	1.00[illegible]
Q2	TRANSISTOR (SI)	PNP		4.	1				0.30313	0.42952	0.45917	0.61559
Q3	TRANSISTOR (SI)	NPN		3.	1				0.10363	0.13880	0.14670	[illegible]
Q4	TRANSISTOR (SI)	NPN		3.	1				0.10363	0.13880	0.14670	0.19074
Q5	TRANSISTOR (SI)	NPN		25.	1				0.15161	0.19881	0.21004	[illegible]
Q6	TRANSISTOR (SI)	NPN		25.	1				0.15161	0.19881	0.21004	[illegible]
Q7	TRANSISTOR (SI)	NPN		1.	1				0.09983	0.13422	0.14192	0.18425
CR1	DIODE (SI)	GP		23.	3				0.51997	0.83482	0.91243	1.38313
CR2	DIODE (ZENER)			1.	1				0.33147	0.41244	0.42958	0.51871
CR3	DIODE (SI)	GP		1.	1				0.05542	0.09799	0.10872	0.17259
CR4	DIODE (SI)	GP		37.	1				0.17259	0.26768	0.29179	0.45145
CR5 6	DIODE (SI)	GP		45.	2				0.42747	0.65926	0.72059	1.1[illegible]
CR711	DIODE (SI)	GP		14.	2				0.17418	0.28934	0.31779	0.4[illegible]
CR14	DIODE (SI)	GP		5.	4				0.25631	0.44584	0.49075	0.7[illegible]
CR16	DIODE (SI)	GP		2.	2				0.11499	0.20225	0.22419	0.35420
CR23	DIODE (SI)	GP		1.	2				0.11083	0.19598	0.21743	0.34517
Q11	TRANSISTOR (SI)	NPN		1.	1				0.09983	0.13422	0.14192	0.18425
R1	RESISTOR(FIXED-COMP)	RCR		10.	1				0.00061	0.00148	0.00177	0.00417
R2	RESISTOR(FIXED-COMP)	RCR		1.	1				0.00052	0.00125	0.00148	0.00344
R3	THERMISTOR	RTH		0.	1				0.52000	0.52000	0.52000	0.52000
R4	RESISTOR(FIXED-COMP)	RCR		1.	1				0.00052	0.00125	0.00148	0.00344
R5	RESISTOR(FIXED-COMP)	RCR		1.	1				0.00052	0.00125	0.00148	0.00344
R6	RESISTOR(FIXED-COMP)	RCR		1.	1				0.00052	0.00125	0.00148	0.00344
R7	RESISTOR(TRIMMER)	RJ		10.	1				5.88156	6.46234	6.62407	7.73401
R11	RESISTOR(FIXED-COMP)	RCR		10.	1				0.00061	0.00148	0.00177	0.00417
R13	RESISTOR(FIXED-COMP)	RCR		1.	1				0.00052	0.00125	0.00148	0.00344
R14	RESISTOR(FIXED-COMP)	RCR		80.	1				0.00213	0.00577	0.00705	0.01[illegible]
R1516	RESISTOR(FIXED-COMP)	RCR		70.	2				0.00356	0.00951	0.01157	0.02969
R17	RESISTOR(FIXED-COMP)	RCR		20.	1				0.00073	0.00180	0.00216	0.00515
R21	RESISTOR(FIXED-COMP)	RCR		40.	1				0.00104	0.00266	0.00320	[illegible]
R22	RESISTOR(FIXED-COMP)	RCR		1.	1				0.00052	0.00125	0.00148	0.00344
R23	RESISTOR(FIXED-COMP)	RCR		10.	1				0.00061	0.00148	0.00177	0.00417
R24	RESISTOR(FIXED-COMP)	RCR		1.	1				0.00052	0.00125	0.00148	0.00344
R25	RESISTOR(FIXED-COMP)	RCR		4.	1				0.00055	0.00132	0.00157	[illegible]
R26	RESISTOR(FIXED-COMP)	RCR		1.	1				0.00052	0.00125	0.00148	0.00344
R12	RESISTOR(FIXED-COMP)	RCR		1.	1				0.00052	0.00125	0.00148	0.00344
R27	RESISTOR(FIXED-WW)	RE6UG		20.	1				0.19124	0.24822	0.26151	0.3[illegible]
R31	RESISTOR(FIXED-COMP)	RCR		1.	1				0.00052	0.00125	0.00148	0.00344
R32	RESISTOR(POWER-FILM)	RNR		2.	1				0.00672	0.00839	0.00877	0.01[illegible]
R33	RESISTOR(POWER-FILM)	RNR		1.	1				0.00665	0.00829	0.00866	0.01[illegible]
R34	RESISTOR(POWER-FILM)	RNR		6.	1				0.00701	0.00879	0.00919	0.01141
R35	RESISTOR(FIXED-COMP)	RCR		1.	1				0.00057	0.00137	0.00163	[illegible]
R36	RESISTOR(FIXED-COMP)	RCR		1.	1				0.00057	0.00137	0.00163	[illegible]
R37	RESISTOR(FIXED-COMP)	RCR		1.	1				0.00057	0.00137	0.00163	[illegible]

CONTRACT MLS PROGRAM EQUIPMENT SMALL COMM AIRB EQ. DATE 2/24/76 REV

ASSEMBLY ACTIVE EQUIP SUBASSEMBLY ANGLE REC/PROC BOARD POWER SUPPLY INTERNAL TEMPERATURE RISE 20

ENVIRONMENT/TEMPERATURE CONDITION PAIRS FOLLOW

(F.R.1) AIRBORNE,INHABITED 0 DEGREES C (F.R.2) AIRBORNE,INHABITED 25 DEGREES C (F.R.3) AIRBORNE,INHABITED 30 DEGREES C (F.R.4) AIRBORNE,INHABITED 54 DEGREES C

CKT SYMBL	PART DESCR	PART TYPE	NON-STD PART NO.	PERCT STRESS	QTY	F.R. SOURCE	REV	ERROR CODE	(F.R.1)	(F.R.2)	(F.R.3)	(F.R.4)
R41	RESISTOR(FIXED-COMP)	RCR		13.	1				0.00064	0.00157	0.00188	0.01444
R42	RESISTOR(FIXED-COMP)	RCR		20.	1				0.00073	0.00180	0.00216	0.00515
RV1	RESISTOR(POWER-FILM)	RD	VARISTOR	10.	1				0.89732	0.94263	0.95266	1.00516
C1-C2	CAPACITOR(ALUM. EL.)	CU		70.	2				2.67684	4.67378	5.34712	11.5[illegible]324
C3	CAPACITOR(TANT. EL.)	CSR		60.	1				0.06190	0.07408	0.07802	0.11171
C4	CAPACITOR(CERAMIC)	CK		50.	1				0.45433	0.48719	0.49404	0.52930
C5	CAPACITOR(DIP. MICA)	CM		2.	1				0.00540	0.01476	0.01804	0.04735
C6	CAPACITOR(CERAMIC)	CK		2.	1				0.02073	0.08657	0.08778	0.09387
C7	CAPACITOR(TANT. EL.)	CSR		5.	1				0.00284	0.00339	0.00357	0.00512
C11	CAPACITOR(TANT. EL.)	CSR		15.	1				0.00104	0.00125	0.00131	0.00[illegible]
C1213	CAPACITOR(CERAMIC)	CK		10.	2				0.16738	0.17969	0.18202	0.1[illegible]464
C14	CAPACITOR(CERAMIC)	CK		20.	1				0.10462	0.11218	0.11376	0.12165
C15	CAPACITOR(TANT. EL.)	CSR		70.	1				0.08998	0.10767	0.11341	0.1[illegible]
C16	CAPACITOR(TANT. EL.)	CSR		50.	1				0.04178	0.05000	0.05266	0.07541
C17	CAPACITOR(TANT. EL.)	CSR		60.	1				0.06190	0.07408	0.07802	0.11171
C21	CAPACITOR(ALUM. EL.)	CU		40.	1				0.54052	0.94375	1.07971	2.35[illegible]2
C22	CAPACITOR(ALUM. EL.)	CU		60.	1				0.97522	1.70274	1.94804	4.21[illegible]
C33	CAPACITOR(CERAMIC)	CK		10.	1				0.08369	0.08975	0.09101	0.09732
L1	POWER XFMR/FILTER			0.	1				0.02820	0.03301	0.03452	0.046[illegible]
L2	POWER XFMR/FILTER			0.	1				0.02820	0.03301	0.03452	0.046[illegible]
L3	POWER XFMR/FILTER			0.	1				0.02820	0.03301	0.03452	0.046[illegible]
L4	POWER XFMR/FILTER			0.	1				0.02820	0.03301	0.03452	0.046[illegible]
L5	POWER XFMR/FILTER			0.	1				0.02820	0.03301	0.03452	0.046[illegible]
L6	POWER XFMR/FILTER			0.	1				0.02820	0.03301	0.03452	0.046[illegible]
L7	POWER XFMR/FILTER			0.	1				0.02820	0.03301	0.03452	0.046[illegible]
L11	POWER XFMR/FILTER			0.	1				0.02820	0.03301	0.03452	0.046[illegible]
T1	POWER XFMR/FILTER			0.	1				0.03452	0.04767	0.05213	0.0[illegible]416
T2	POWER XFMR/FILTER			0.	1				0.03452	0.04767	0.05213	0.0[illegible]416
	CONNECTOR			0.	1				0.10565	0.19773	0.22268	0.3[illegible]513

TOTAL FAILURE RATES FOR THIS LEVEL ARE........ 18.49953 24.56127 26.40634 41.[illegible]

CONTRACT MLS PROGRAM EQUIPMENT SMALL COMM AIRB EQ. DATE 2/24/76 REV

ASSEMBLY ACTIVE EQUIP SUBASSEMBLY ANGLE REC/PROC BOARD SYNTHESIZER INTERNAL TEMPERATURE RISE 20

ENVIRONMENT/TEMPERATURE CONDITION PAIRS FOLLOW
(F.R.1) AIRBORNE,INHABITED U DEGREES C
(F.R.2) AIRBORNE,INHABITED 25 DEGREES C
(F.R.3) AIRBORNE,INHABITED 30 DEGREES C
(F.R.4) AIRBORNE,INHABITED 54 DEGREES C

CKT SYMBL	PART DESCR	PART TYPE	NON-STD PART NO.	PERCT STRESS	QTY	F.R. SOURCE	REV	ERROR CODE	(F.R.1)	(F.R.2)	(F.R.3)	(F.R.4)
U1	MICROELEC. SSI/MSI			0.	1				1.18215	1.55638	1.75000	4.33952
U2	MICROELEC. SSI/MSI			0.	1				0.41779	0.47331	0.50204	0.88624
U3	MICROELEC. SSI/MSI			0.	1				0.72560	0.87932	0.95884	2.02247
U4 U7	MICROELEC. SSI/MSI			0.	2				0.83557	0.94662	1.00407	1.77246
U5	MICROELEC. LINEAR			0.	1				0.74303	0.81748	0.85590	1.37113
U6 U8	MICROELEC. SSI/MSI			0.	2				1.38951	1.67337	1.82024	3.78444
U9	MICROELEC. LINEAR			0.	1				1.00575	1.11902	1.17763	1.97140
U1011	MICROELEC. LINEAR			0.	2				2.81969	3.18135	3.36847	5.87112
U1214	MICROELEC. SSI/MSI			0.	3				3.03152	3.87607	4.31302	10.15607
U15	ROM MEMORY			0.	1				4.20878	10.21357	13.09458	49.13649
U16	MICROELEC. SSI/MSI			0.	1				0.69120	0.73235	0.74676	0.86616
U17	MICROELEC. SSI/MSI			0.	1				0.69120	0.73235	0.74676	0.86616
U18	MICROELEC. LINEAR			0.	1				0.96239	1.06895	1.12408	1.86142
Q1	TRANSISTOR (SI)	NPN		3.	1				0.06448	0.08637	0.09128	0.11143
Q2	TRANSISTOR (SI)	PNP		65.	1				0.22022	0.33018	0.36543	0.70551
Q3	TRANSISTOR (SI)	NPN		35.	1				1.98190	2.61236	2.76941	3.78307
CR1 2	DIODE (SI)	GP		15.	2				0.17995	0.29766	0.32672	0.49971
CR313	DIODE (SI)	GP		1.	11				0.60957	1.07787	1.19589	1.80846
CR14	DIODE(VAR/REC/TUN)			10.	1				2.68772	3.60719	3.81277	4.94614
CR15	DIODE(VAR/REC/TUN)			10.	1				2.68772	3.60719	3.81277	4.94604
	DIODE(MW MIXER)	(SI)		10.	2				18.42584	20.62199	21.10993	24.65461
Q11	TRANSISTOR (SI)	NPN		25.	1				0.15161	0.19881	0.21004	0.27918
Q1213	TRANSISTOR (SI)	NPN		50.	2				0.60927	0.82891	0.88858	1.31951
Q14	TRANSISTOR (SI)	NPN		50.	1				1.01545	1.38152	1.48096	2.19934
CR12	DIODE (ZENER)			15.	1				0.39898	0.48744	0.50776	0.61370
R1	RESISTOR(FIXED-COMP)	RCR		1.	6				0.00311	0.00747	0.00891	0.02065
R2	RESISTOR(FIXED-COMP)	RCR		1.	1				0.00130	0.00311	0.00371	0.00860
R7	RESISTOR(FIXED-COMP)	RCR		1.	1				0.00052	0.00125	0.00148	0.00344
R8	RESISTOR(FIXED-COMP)	RCR		1.	4				0.00207	0.00498	0.00594	0.01377
R11	RESISTOR(FIXED-COMP)	RCR		1.	2				0.00104	0.00249	0.00297	0.00688
R12	RESISTOR(FIXED-COMP)	RCR		3.	15				0.00806	0.01942	0.02316	0.05356
R14	RESISTOR(FIXED-COMP)	RCR		1.	5				0.00259	0.00623	0.00742	0.01721
R16	RESISTOR(FIXED-COMP)	RCR		3.	2				0.00108	0.00259	0.00309	0.00719
R34	RESISTOR(FIXED-COMP)	RCR		3.	2				0.00108	0.00259	0.00309	0.00719
R54	RESISTOR(FIXED-COMP)	RCR		30.	1				0.00087	0.00219	0.00263	0.00636
R56	RESISTOR(FIXED-COMP)	RCR		5.	6				0.00334	0.00808	0.00964	0.02249
R57	RESISTOR(FIXED-COMP)	RCR		30.	1				0.00087	0.00219	0.00263	0.00636
R58	RESISTOR(FIXED-COMP)	RCR		15.	1				0.00067	0.00163	0.00196	0.00463
R59	RESISTOR(FIXED-COMP)	RCR		4.	4				0.00219	0.00528	0.00630	0.01467
R61	RESISTOR(FIXED-COMP)	RCR		3.	1				0.00054	0.00129	0.00154	0.00359
R62	RESISTOR(FIXED-COMP)	RCR		3.	1				0.00054	0.00129	0.00154	0.00359
R64	RESISTOR(FIXED-COMP)	RCR		1.	4				0.00207	0.00498	0.00594	0.01377
R67	RESISTOR(FIXED-COMP)	RCR		1.	2				0.00104	0.00249	0.00297	0.00688
R77	RESISTOR(FIXED-COMP)	RCR		30.	1				0.00087	0.00219	0.00263	0.00636
R30	RESISTOR(TRIMMER)	RJ		1.	1				5.65199	6.15519	6.29727	7.2[illegible]
R68	RESISTOR(FIXED-COMP)	RCR		60.	1				0.00149	0.00392	0.00475	0.01201

CONTRACT MLS PROGRAM EQUIPMENT SMALL COPN AIMP FQ. DATE 2/26/76 REV

ASSEMBLY ACTIVE EQUIP SUBASSEMBLY ANGLE REC/PROC BOARD SYNTHESIZER INTERNAL TEMPERATURE RISE 20

ENVIRONMENT/TEMPERATURE CONDITION PAIRS FOLLOW
(F.R.1) AIRBORNE,INHABITED 0 DEGREES C (F.R.2) AIRBORNE,INHABITED 25 DEGREES C (F.R.3) AIRBORNE,INHABITED 30 DEGREES C (F.R.4) AIRBORNE,INHABITED 54 DEGREES C

CKT SYMBL	PART DESCR	PART TYPE	NON-STD PART NO.	PERCT STRESS	QTY	F.R. SOURCE	REV	ERROR CODE	(F.R.1)	(F.R.2)	(F.R.3)	(F.R.4)
R69	RESISTOR(FIXED-COMP)	RCR		1.	3				0.00156	0.00374	0.00445	0.01043
R70	RESISTOR(FIXED-COMP)	RCR		1.	1				0.00052	0.00125	0.00148	0.00344
R7172	RESISTOR(FIXED-COMP)	RCR		1.	4				0.00207	0.00498	0.00594	0.01[illegible]77
R73	RESISTOR(FIXED-COMP)	RCR		1.	1				0.00052	0.00125	0.00148	0.00344
R74	RESISTOR(FIXED-COMP)	RCR		60.	1				0.00149	0.00392	0.00475	0.01201
R7576	RESISTOR(FIXED-COMP)	RCR		60.	2				0.00298	0.00783	0.00950	0.02402
R94	RESISTOR(FIXED-COMP)	RCR		50.	1				0.00125	0.00322	0.00390	[illegible]
R81	RESISTOR(FIXED-COMP)	RCR		60.	2				0.00298	0.00783	0.00950	0.02402
R82	RESISTOR(FIXED-COMP)	RCR		10.	1				0.00061	0.00148	0.00177	0.00416
	THERMISTOR	RTH		20.	1				1.60000	1.60000	1.60000	1.60000
C1	CAPACITOR(CERAMIC)	CK		25.	10				1.17346	1.24954	1.26534	1.34[illegible]
C6	CAPACITOR(CERAMIC)	CK		35.	3				0.57710	0.61451	0.62228	0.66[illegible]6
C14	CAPACITOR(CERAMIC)	CK		15.	2				0.16724	0.17809	0.18034	0.19[illegible]5
C15	CAPACITOR(CERAMIC)	CK		20.	2				0.19271	0.20520	0.20780	0.22[illegible]1
C21	CAPACITOR(CERAMIC)	CK		40.	1				0.25052	0.26674	0.27014	0.28[illegible]3
C22	CAPACITOR(CERAMIC)	CK		10.	10				0.77084	0.82081	0.83119	[illegible]
C33	CAPACITOR(CERAMIC)	CK		30.	4				0.59465	0.63320	0.64120	0.6[illegible]6
C8	CAPACITOR(TANT. EL.)	CSR		33.	1				0.00884	0.01058	0.01114	0.015[illegible]
C1820	CAPACITOR(TANT. EL.)	CSR		33.	2				0.01768	0.02115	0.02228	[illegible]
C29	CAPACITOR(TANT. EL.)	CSR		33.	1				0.00884	0.01058	0.01114	0.015[illegible]
C37	CAPACITOR(CERAMIC)	CK		5.	3				0.21449	0.22755	0.23025	0.24[illegible]
C3843	CAPACITOR(CERAMIC)	CK		5.	6				0.42897	0.45509	0.46050	0.4[illegible]
C44	CAPACITOR(VARIABLE)	PC		5.	1				0.03241	0.06914	0.08045	0.1[illegible]
C4546	CAPACITOR(VAR. CER.)	CV		1.	2				0.11882	0.15565	0.16[illegible]	[illegible]0513
C4748	CAPACITOR(VAR. CER.)	CV		1.	2				0.11882	0.15565	0.16788	0.20513
C50	CAPACITOR(CERAMIC)	CK		10.	12				0.92501	0.98497	0.99743	1.0[illegible]
C53	CAPACITOR(VAR. CER.)	CV		10.	4				0.28594	0.37459	0.40742	[illegible]
C52	CAPACITOR(DIP. MICA)	CM		10.	1				0.00549	0.01499	0.01[illegible]32	[illegible]
C57	CAPACITOR(VARIABLE)	PC		5.	2				0.06483	0.13828	0.16091	[illegible]
C60	CAPACITOR(CERAMIC)	CK		5.	3				0.24323	0.26082	0.26440	[illegible]
C65	CAPACITOR(CERAMIC)	CK		1.	2				0.16141	0.17309	0.17552	[illegible]
	RF TRANSFORMER/COIL			0.	10				0.42304	0.49510	0.51782	0.70821
	CONNECTOR			0.	2				0.86356	1.41953	1.57563	2.5[illegible]
	CONNECTOR			0.	1				0.11804	0.22356	0.25222	0.4[illegible]

TOTAL FAILURE RATES FOR THIS LEVEL ARE........ 62.80386 79.44207 85.[illegible]0540 1[illegible]1441

CONTRACT MLS PROGRAM   EQUIPMENT SMALL COMM AIRR EQ.   DATE 2/26/76 REV

ASSEMBLY ACTIVE EQUIP   SUBASSEMBLY ANGLE REC/PROC   BOARD FRONT END   INTERNAL TEMPERATURE RISE 20

ENVIRONMENT/TEMPERATURE CONDITION PAIRS FOLLOW

(F.R.1) AIRBORNE,INHABITED 0 DEGREES C   (F.R.2) AIRBORNE,INHABITED 25 DEGREES C   (F.R.3) AIRBORNE,INHABITED 30 DEGREES C   (F.R.4) AIRBORNE,INHABITED 54 DEGREES C

CKT SYMBL	PART DESCR	PART TYPE	NON-STD PART NO.	PERCT STRESS	QTY	F.R. SOURCE	REV	ERROR CODE	(F.R.1)	(F.R.2)	(F.R.3)	(F.R.4)
	DIODE(MW MIXER)	(S1)		10.	2				18.42584	20.62199	21.10993	24.05411
TOTAL FAILURE RATES FOR THIS LEVEL ARE........									18.42583	20.62199	21.10993	24.05400

CONTRACT MLS PROGRAM   EQUIPMENT SMALL COMM AIRR EQ.   DATE 2/26/76   REV

ASSEMBLY ACTIVE EQUIP   SUBASSEMBLY ANGLE REC/PROC   BOARD R.F. MODULE   INTERNAL TEMPERATURE RISE 20

ENVIRONMENT/TEMPERATURE CONDITION PAIRS FOLLOW
(F.R.1) AIRBORNE,INHABITED 0 DEGREES C   (F.R.2) AIRBORNE,INHABITED 25 DEGREES C   (F.R.3) AIRBORNE,INHABITED 30 DEGREES C   (F.R.4) AIRBORNE,INHABITED 54 DEGREES C

CKT SYMBL	PART DESCR	PART TYPE	NON-STD PART NO.	PERCT STRESS	QTY	F.R. SOURCE	REV	ERROR CODE	(F.R.1)	(F.R.2)	(F.R.3)	(F.R.4)
U11	QUARTZ CRYSTAL		FILTER XTAL	0.	6				1.20000	1.20000	1.20000	1.20000
Y1	QUARTZ CRYSTAL			0.	1				0.20000	0.20000	0.20000	0.20000
U1	MICROELEC. LINEAR			0.	1				0.96239	1.06895	1.12408	1.[illegible]
A1-A6	MICROELEC. LINEAR			0.	6				2.43669	2.62987	2.72981	4.[illegible]
U3	MICROELEC. LINEAR			0.	1				0.76989	0.84810	0.88856	1.42976
U4	MICROELEC. SSI/MSI			0.	1				0.41639	0.43249	0.43813	0.47474
U5	MICROELEC. SSI/MSI			0.	1				0.69120	0.73235	0.74676	0.86616
U2	MICROELEC. LINEAR			0.	1				1.06809	1.19120	1.25489	2.10777
U11	MICROELEC. LINEAR			0.	1				0.76989	0.84810	0.88856	1.42976
A7	MICROELEC. LINEAR			0.	1				0.79601	0.87792	0.92029	1.4[illegible]
A8	MICROELEC. LINEAR			0.	1				0.76989	0.84810	0.88856	1.42970
U6	MICROELEC. SSI/MSI			0.	1				0.41639	0.43249	0.43813	0.47474
Q1	TRANSISTOR (SI)	NPN		10.	1				0.26952	0.35705	0.37696	0.45943
Q2	FET			27.	1				1.21693	1.59750	1.68666	2.22533
Q3	TRANSISTOR (SI)	NPN		9.	1				0.11554	0.15328	0.16184	0.21004
CR1	DIODE (SI)	GP		9.	1				0.07368	0.12514	0.13792	0.21374
U2	DIODE(MW MIXER)	(SI)		5.	4				35.81063	40.08663	41.66759	46.29[illegible]
Q4-Q7	TRANSISTOR (SI)	NPN		2.	4				0.33906	0.45409	0.48100	0.62422
Q13	TRANSISTOR (SI)	NPN		4.	1				0.14075	0.18819	0.19886	0.257[illegible]
CR2-4	DIODE (ZENER)			15.	2				0.79796	0.97498	1.01352	1.22[illegible]
CR3	DIODE (SI)	GP		5.	2				0.12815	0.22192	0.24537	0.3[illegible]
R1 9	RESISTOR(FIXED-COMP)	RCR		3.	2				0.00108	0.00259	0.00309	[illegible]
R2	RESISTOR(FIXED-COMP)	RCR		12.	1				0.00063	0.00154	0.00184	0.00434
R3	RESISTOR(FIXED-COMP)	RCR		1.	1				0.00052	0.00125	0.00148	0.00344
R4	RESISTOR(FIXED-COMP)	RCR		2.	6				0.00317	0.00762	0.00906	[illegible]
R5	RESISTOR(FIXED-COMP)	RCR		5.	1				0.00056	0.00135	0.00161	[illegible]
R6	RFSISTOR(FIXED-COMP)	RCR		33.	1				0.00092	0.00232	0.00279	[illegible]
R7	RESISTOR(FIXED-COMP)	RCR		1.	10				0.00519	0.01244	0.01484	0.03442
R8	RESISTOR(FIXED-COMP)	RCR		5.	1				0.00056	0.00135	0.00161	0.00375
R10	RESISTOR(FIXED-COMP)	RCR		1.	1				0.00052	0.00125	0.00148	0.00344
R11	RESISTOR(FIXED-COMP)	RCR		7.	1				0.00058	0.00140	0.00167	0.00391
R12	RESISTOR(FIXED-COMP)	RCR		19.	1				0.00072	0.00177	0.00212	0.00504
R13	RESISTOR(FIXED-COMP)	RCR		10.	1				0.00061	0.00148	0.00177	0.00414
R1418	RESISTOR(FIXED-COMP)	RCR		1.	2				0.00104	0.00249	0.00297	[illegible]
R1519	RESISTOR(TRIMMER)	RJ		1.	3				18.65158	20.31212	20.78081	24.03[illegible]
R1617	RESISTOR(FIXED-COMP)	RCR		1.	12				0.00622	0.01495	0.01791	0.041[illegible]
R2021	RESISTOR(FIXED-COMP)	RCR		1.	12				0.00622	0.01495	0.01781	[illegible]
R22	RESISTOR(FIXED-COMP)	RCR		1.	1				0.00052	0.00125	0.00148	0.00344
R23	RESISTOR(FIXED-COMP)	RCR		33.	1				0.00092	0.00232	0.00279	[illegible]
R24	RESISTOR(FIXED-COMP)	RCR		1.	1				0.00052	0.00125	0.00148	0.00344
C1028	CAPACITOR(CERAMIC)	CK		2.	7				0.56509	0.60596	0.61449	[illegible]
C109	CAPACITOR(CERAMIC)	CK		20.	3				0.28906	0.30780	0.31170	0.321[illegible]
C110	CAPACITOR(VAR. CER.)	CV		10.	2				0.14297	0.18730	0.2[illegible]	[illegible]
C111	CAPACITOR(DIP. MICA)	CM		1.	7				0.03781	0.10730	[illegible]	[illegible]
C112	CAPACITOR(CERAMIC)	CK		10.	4				0.50215	0.53947	[illegible]	[illegible]
C202	CAPACITOR(CERAMIC)	CK		1.	4				0.29733	0.31651	[illegible]	[illegible]

CONTRACT MLS PROGRAM EQUIPMENT SMALL COMM AIRD EQ. DATE 2/26/76 REV

ASSEMBLY ACTIVE EQUIP SUBASSEMBLY ANGLE REC/PROC BOARD R.F. MODULE INTERNAL TEMPERATURE RISE 20

ENVIRONMENT/TEMPERATURE CONDITION PAIRS FOLLOW
(F.R.1) AIRBORNE,INHABITED 0 DEGREES C
(F.R.2) AIRBORNE,INHABITED 25 DEGREES C
(F.R.3) AIRBORNE,INHABITED 30 DEGREES C
(F.R.4) AIRBORNE,INHABITED 54 DEGREES C

CKT SYMBL	PART DESCR	PART TYPE	NON-STD PART NO.	PERCT STRESS	QTY	F.R. SOURCE	REV	ERROR CODE	(F.R.1)	(F.R.2)	(F.R.3)	(F.R.4)
C213	CAPACITOR(CERAMIC)	CK		11.	1				0.08468	0.09081	0.09208	0.09847
C209	CAPACITOR(CERAMIC)	CK		15.	3				0.25087	0.26713	0.27051	[illegible]
C231	CAPACITOR(CERAMIC)	CK		0.	1				0.07433	0.07915	0.08115	[illegible]
C224	CAPACITOR(CERAMIC)	CK		30.	3				0.44599	0.47490	0.48090	[illegible]
C227	CAPACITOR(CERAMIC)	CK		10.	1				0.07708	0.08208	0.08312	[illegible]
C204	CAPACITOR(TANT. EL.)	CSR		10.	9				0.02587	0.03095	0.03260	[illegible]
C134	CAPACITOR(CERAMIC)	CK		9.	3				0.24865	0.26663	0.27038	[illegible]
C211	CAPACITOR(CERAMIC)	CK		9.	2				0.15268	0.16257	0.16463	[illegible]
C531	CAPACITOR(CERAMIC)	CK		24.	2				0.24405	0.26170	0.26538	[illegible]
C610	CAPACITOR(CERAMIC)	CK		12.	2				0.15144	0.16066	0.16257	[illegible]
C712	CAPACITOR(CERAMIC)	CK		1.	2				0.14234	0.15100	0.15280	[illegible]
C813	CAPACITOR(VARIABLE)	PC		2.	2				0.06462	0.13783	0.16038	[illegible]
C915	CAPACITOR(CERAMIC)	CK		3.	2				0.14247	0.15115	0.15295	[illegible]
C14	CAPACITOR(CERAMIC)	CK		6.	1				0.07493	0.07978	0.08079	[illegible]
C1623	CAPACITOR(VARIABLE)	PC		5.	2				0.06483	0.13828	0.16091	[illegible]
C17	CAPACITOR(CERAMIC)	CK		24.	1				0.12202	0.13085	0.13269	[illegible]
C1820	CAPACITOR(CERAMIC)	CK		24.	2				0.24405	0.26170	0.26538	[illegible]
C19	CAPACITOR(CERAMIC)	CK		5.	1				0.08108	0.08694	0.08816	[illegible]
C21	CAPACITOR(CERAMIC)	CK		12.	1				0.07572	0.08033	0.08129	[illegible]
C22	CAPACITOR(CERAMIC)	CK		24.	1				0.11239	0.11967	0.12119	[illegible]
C24	CAPACITOR(CERAMIC)	CK		15.	1				0.08362	0.08904	0.09017	[illegible]
C25	CAPACITOR(CERAMIC)	CK		12.	1				0.07572	0.08033	0.08129	[illegible]
C2627	CAPACITOR(CERAMIC)	CK		24.	2				0.24405	0.26170	0.26538	[illegible]
C2829	CAPACITOR(CERAMIC)	CK		12.	2				0.17174	0.18416	0.18675	[illegible]
C30	CAPACITOR(CERAMIC)	CK		24.	1				0.12202	0.13085	0.13269	[illegible]
J1	CONNECTOR			0.	2				0.56877	0.97455	1.03076	1.65102
J2	CONNECTOR			0.	1				0.28414	0.46727	0.51538	[illegible]
	CONNECTOR			0.	1				0.07326	0.13874	0.15653	[illegible]
	CONNECTOR			0.	3				0.86356	1.41953	1.56563	[illegible]
L1	RF TRANSFORMER/COIL			0.	1				0.04230	0.04951	0.05178	[illegible]
L2-5	RF TRANSFORMER/COIL			0.	4				0.16922	0.19804	0.20713	[illegible]
L6-8	RF TRANSFORMER/COIL			0.	3				0.12691	0.14853	0.15535	[illegible]
L9	RF TRANSFORMER/COIL			0.	1				0.04230	0.04951	0.05178	[illegible]
U2	RF TRANSFORMER/COIL			0.	2				0.08461	0.09902	0.10756	0.14064
L101	RF TRANSFORMER/COIL			0.	8				0.37313	0.43987	0.46655	[illegible]
U10	RF TRANSFORMER/COIL			0.	1				0.04230	0.04951	0.05178	[illegible]

TOTAL FAILURE RATES FOR THIS LEVEL ARE........ 76.15226 85.86808 88.42922 [illegible]

CONTRACT MLS PROGRAM EQUIPMENT SMALL COMM AIRR EQ. DATE 2/26/76 REV

ASSEMBLY ACTIVE EQUIP SUBASSEMBLY ANGLE REC/PROC BOARD MAIN FRAME INTERNAL TEMPERATURE RISE 20

ENVIRONMENT/TEMPERATURE CONDITION PAIRS FOLLOW
(F.R.1) AIRBORNE,INHABITED 0 DEGREES C
(F.R.2) AIRBORNE,INHABITED 25 DEGREES C
(F.R.3) AIRBORNE,INHABITED 30 DEGREES C
(F.R.4) AIRBORNE,INHABITED 54 DEGREES C

CKT SYMBL	PART DESCR	PART TYPE	NON-STD PART NO.	PERCT STRESS	QTY	F.R. SOURCE	REV	ERROR CODE	(F.R.1)	(F.R.2)	(F.R.3)	(F.R.4)
	CONNECTOR			0.	1				0.43178	0.70977	0.78281	1.25405
	CONNECTOR			0.	1				0.08115	0.15368	0.17338	0.30251
	CONNECTOR			0.	1				0.38267	0.72472	0.81764	1.42563

TOTAL FAILURE RATES FOR THIS LEVEL ARE........ 0.89559 1.58816 1.77383 2.98198

CONTRACT MLS PROGRAM   EQUIPMENT SMALL COMM AIRR EQ.   DATE 2/26/76   REV

ASSEMBLY ACTIVE EQUIP   SUBASSEMBLY ANTENNA SUBSYST   BOARD   INTERNAL TEMPERATURE RISE 0

ENVIRONMENT/TEMPERATURE CONDITION PAIRS FOLLOW

(F.R.1) AIRBORNE,INHABITED 0 DEGREES C   (F.R.2) AIRBORNE,INHABITED 25 DEGREES C   (F.R.3) AIRBORNE,INHABITED 30 DEGREES C   (F.R.4) AIRBORNE,INHABITED 54 DEGREES C

CKT SYMBL	PART DESCR	PART TYPE	NON-STD PART NO.	PERCT STRESS	QTY	F.R. SOURCE	REV	ERROR CODE	(F.R.1)	(F.R.2)	(F.R.3)	(F.R.4)
	CONNECTOR			0.	4				1.13844	1.91052	2.11144	3.35622
TOTAL FAILURE RATES FOR THIS LEVEL ARE........									1.13843	1.91052	2.11143	3.35621

CONTRACT MLS PROGRAM EQUIPMENT SMALL COMM AIRB EQ. DATE 2/26/76 REV

ASSEMBLY ACTIVE EQUIP SUBASSEMBLY CONTROL PANEL BOARD INTERNAL TEMPERATURE RISE 20

ENVIRONMENT/TEMPERATURE CONDITION PAIRS FOLLOW

(F.R.1) AIRBORNE,INHABITED 0 DEGREES C (F.R.2) AIRBORNE,INHABITED 25 DEGREES C (F.R.3) AIRBORNE,INHABITED 30 DEGREES C (F.R.4) AIRBORNE,INHABITED 54 DEGREES C

CKT SYMBL	PART DESCR	PART TYPE	NON-STD PART NO.	PERCT STRESS	QTY	F.R. SOURCE	REV	ERROR CODE	(F.R.1)	(F.R.2)	(F.R.3)	(F.R.4)
U1 U4	ROM MEMORY			0.	4				9.85816	24.23436	31.13185	115.01211
U5 U6	ROM MEMORY			0.	2				2.04615	5.16197	6.65[illegible]	24.87[illegible]
U7 U8	MICROELEC. SSI/MSI			0.	2				2.55138	2.80428	2.89287	3.62[illegible]
U9U10	MICROELEC. SSI/MSI			0.	2				2.34553	2.56254	2.63855	3.2[illegible]
U11-3	MICROELEC. SSI/MSI			0.	3				1.24918	1.29748	1.31440	1.45452
U14	MICROELEC. SSI/MSI			0.	1				0.48273	0.50392	0.51134	0.572[illegible]
U15	MICROELEC. SSI/MSI			0.	1				0.41639	0.43249	0.43813	0.4[illegible]
U16	MICROELEC. LINEAR			0.	1				0.94010	1.04326	1.09663	1.81041
U17	MICROELEC. LINEAR			0.	1				0.84626	0.93542	0.98155	1.59851
	TRANSISTOR (SI)	PNP		3.	1				0.14226	0.20216	0.21573	0.2[illegible]12
	TRANSISTOR (SI)	PNP		60.	1				0.56896	0.56896	0.56896	0.56896
	DIODE (GE)	GP		1.	1				0.05879	0.15619	0.18795	0.4743[illegible]
	DIODE (SI)	GP		1.	1				0.05542	0.09799	0.10872	0.17259
	RESISTOR(POT-COMP)	RV		40.	1				11.00037	14.22634	15.23927	23.727[illegible]
R1	RESISTOR(FIXED-COMP)	RCR		3.	1				0.00054	0.00129	0.00154	0.003[illegible]
R2	RESISTOR(FIXED-COMP)	RCR		10.	1				0.00061	0.00148	0.00177	0.00416
R3	RESISTOR(FIXED-COMP)	RCR		1.	1				0.00057	0.00137	0.00163	0.00379
R4	RESISTOR(FIXED-COMP)	RCR		1.	1				0.00057	0.00137	0.00163	0.0037[illegible]
R6	RESISTOR(FIXED-COMP)	RCR		3.	1				0.00054	0.00129	0.00154	0.00359
R7	RESISTOR(FIXED-COMP)	RCR		3.	1				0.00054	0.00129	0.00154	0.00359
R8	RESISTOR(FIXED-COMP)	RCR		3.	1				0.00054	0.00129	0.00154	0.00359
R9	RESISTOR(FIXED-COMP)	RCR		8.	1				0.00059	0.00143	0.00170	0.00399
R10	RESISTOR(POWER-FILM)	RNR		4.	1				0.00686	0.00858	0.00896	0.01113
R11	RESISTOR(POWER-FILM)	RNR		3.	1				0.00679	0.00848	0.00887	0.0109[illegible]
R12	RESISTOR(FIXED-COMP)	RCR		1.	1				0.0008[illegible]	0.00199	0.00237	0.00551
R13	RESISTOR(FIXED-COMP)	RCR		1.	1				0.0005[illegible]	0.00125	0.00148	0.00344
R14	RESISTOR(FIXED-COMP)	RCR		7.	1				0.00058	0.00140	0.00167	0.003[illegible]1
	SWITCH, TOGGLE/PB			0.	3				1.26000	1.26000	1.26000	1.2[illegible]
	SWITCH, ROTARY-MP			0.	9				98.49598	98.49598	98.49598	98.49598
	CONNECTOR			0.	1				0.26981	0.51098	0.57650	1.0[illegible]
	CONNECTOR			0.	1				0.24516	0.46430	0.52383	0.91[illegible]
	LAMP, INCANDESCENT			0.	16				16.00000	16.00000	16.00000	16.00000
TOTAL FAILURE RATES FOR THIS LEVEL ARE........									148.85260	170.99105	180.87527	295.[illegible]

ASSEMBLY	SUBASSEMBLY	BOARD		(F.R.1)	(F.R.2)	(F.R.3)	(F.R.4)
ACTIVE EQUIP	ANGLE REC/PROC	ENVELOPE PROC	(Q= 1)	38.56366	46.91083	50.74400	9[illegible].7[illegible]153
ACTIVE EQUIP	ANGLE REC/PROC	DIGITAL PROC	(Q= 1)	83.52258	105.75352	114.78036	208.58456
ACTIVE EQUIP	ANGLE REC/PROC	PROCESSOR I/O	(Q= 1)	37.09559	49.12817	54.60913	119.[illegible]454
ACTIVE EQUIP	ANGLE REC/PROC	POWER SUPPLY	(Q= 1)	18.49953	24.56127	26.40634	41.[illegible]2737
ACTIVE EQUIP	ANGLE REC/PROC	SYNTHESIZER	(Q= 1)	62.80326	79.44207	85.60540	150.61441
ACTIVE EQUIP	ANGLE REC/PROC	FRONT END	(Q= 1)	18.42583	20.62199	21.10993	24.05410
ACTIVE EQUIP	ANGLE REC/PROC	R.F. MODULE	(Q= 1)	74.15226	85.86808	88.42922	107.3[illegible]512
ACTIVE EQUIP	ANGLE REC/PROC	MAIN FRAME	(Q= 1)	0.89559	1.58816	1.77383	2.911[illegible]
ACTIVE EQUIP	ANTENNA SUBSYST		(Q= 1)	1.13843	1.91052	2.11143	3.5[illegible]21
ACTIVE EQUIP	CONTROL PANEL		(Q= 1)	148.85260	170.99105	180.87527	295.6[illegible]
OVERALL FAILURE RATES FOR THIS EQUIPMENT ARE				485.94976	586.77551	626.44470	1051.1[illegible]21

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1	247	0.15001	0.36650	0.43824	1.03422
3	15	0.10465	0.13105	0.13709	0.17013
4	1	0.89732	0.94263	0.95266	1.00586
13	1	0.19124	0.24822	0.26151	0.33590
29	5	30.18512	32.92964	33.70208	39.05239
30	1	11.00036	14.22634	15.23926	23.72709
31	1	0.52000	0.52000	0.52000	0.52000
32	1	1.60000	1.60000	1.60000	1.60000
38	69	6.40311	6.86624	6.96282	7.44559
39	64	6.50980	6.93182	7.01945	7.45576
40	17	1.23115	1.30611	1.32164	1.39879
46	9	0.04869	0.13304	0.16266	0.42687
57	20	0.32871	0.39334	0.41430	0.59321
58	4	4.19257	7.32026	8.37487	18.14212
59	10	0.66653	0.87318	0.94739	1.71177
64	7	0.22668	0.48354	0.56264	1.16435
65	95	73.60118	81.44323	84.79643	122.12950
66	39	40.56203	45.40933	47.91718	81.45832
67	1	25.00000	25.00000	25.00000	25.00000
68	7	16.24253	32.12973	39.41737	124.76637
69	13	48.65374	88.48005	106.47929	314.51721
70	3	1.25999	1.25999	1.25999	1.25999
75	9	98.49598	98.49598	98.49598	98.49598
118	8	1.59999	1.59999	1.59999	1.59999
122	16	16.00000	16.00000	16.00000	16.00000
135	19	5.39771	7.20512	7.65626	10.58578
136	5	1.74752	2.22454	2.34516	3.18387
138	2	0.78661	1.49052	1.71935	4.33810
139	1	1.21692	1.59750	1.68666	2.22533
141	38	3.18345	5.32723	5.86607	9.17627
142	1	0.05878	0.15618	0.18794	0.47437
143	5	2.06566	2.53557	2.64201	3.26893
148	8	72.66230	81.33061	83.22746	94.40759
149	2	5.37545	7.21437	7.62554	9.89207
177	10	0.29466	0.35939	0.38042	0.56337
178	30	1.30382	1.52908	1.60575	2.33057
180	23	6.18652	10.71620	11.92053	19.71327

APPENDIX F

THE EFFECT OF RAIN ON
THE MLS PHASE III RADOMES

APPENDIX F

THE EFFECT OF RAIN ON THE MLS PHASE III RADOMES

The Basic Narrow and Small Community systems at NAFEC have experienced monitor shutdown several times this summer during heavy rainfall. The system monitor indicated a Beam ERP fault on the azimuth antennas. The Beam ERP is set to indicate a fault at the -3.0 dB level. During a recent storm the Beam ERP was closely monitored and a level of -2.5 dB was observed during a period of fairly heavy rainfall. The drop in ERP was suspected to be caused by rain water on the array and monitor horn radomes. This was verified with a simulated rainfall test using a NAFEC Fire Department engine to spray water on the antenna. A -11 dB reduction in Beam ERP was experienced when the array antenna was sprayed and -4 dB when the monitor horn was sprayed. These were the maximum values observed under an extremely heavy rainfall simulation, probably not naturally possible.

The significant difference between the two antennas may be due to the difference in the physical size of the two antenna radomes or the differences in the radome material. The larger area of the array radome may allow a thicker water film to build up on its surface. The different radome materials can have significantly different water-shedding or wettability properties. The monitor horn radome is teflon fiberglass which has excellent water shedding properties due to its wax-like surface finish. The array radome material is a polyester resin and its water-shedding properties are probably highly dependent on the condition of its surface finish. A dull, weathered surface would be considerably worse than a new, shiny surface. It should be noted that the Basic Narrow array radome has been in the field over a year and its surface is probably fairly weathered due to exposure to the elements. The technician on-site reports that he observed a much higher degree of water filming and surface wetness

on the array radome as compared to the monitor horn radome.

RF attenuation due to rain water on radomes is a well known problem and has been extensively investigated. See attached Essco paper, "The Effect of Rain on Satellite Communications Earth Terminal Rigid Radomes". Several radome manufacturers have addressed this problem in their design by employing a Dupont Tedlar film on the radome surface. This material not only has good water-shedding properties, but also provides excellent protection against ultraviolet radiation and solar heating. Tests have demonstrated that a one-mil thick Tedlar film has a life expectancy in excess of 30 years.

A one-mil thick film of Tedlar is normally applied to the radome outer surface at the time of manufacture by a bonding process. Tedlar tape is also available, coming in 72-yard rolls up to 36 inches wide, and having a thickness of approximately 3-mils, which could be applied to the existing MLS radomes in the field.

A suggestion was made that we simply wax the array radomes in the field to increase their water-shedding properties, understanding that a wax finish can only be expected to last four to five weeks. In view of this, it is suggested that we wax the Basic Narrow radome in the field as a temporary fix and repeat the simulated rain test to determine if this alone is adequate to solve the rain attenuation problem. If not, then an overhanging roof extension can be added to the antenna case to protect the radome from direct rainfall.

If waxing the radome significantly helps the rain attenuation problem, than a permanent fix would be to cover the existing radomes in the field with Tedlar Tape. Two 72-yard rolls of Tedlar tape have been ordered for this purpose, one 6 inches wide and one 36 inches wide. A two-week delivery has been quoted by the supplier.

NOTE: The on-site technician reports that he waxed the Basic Narrow radome and repeated the rain test. The maximum loss dropped from -11 dB to -7 dB. The next step should be to repeat the test with the Tedlar tape on the radome.

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NUMBER 4

THE EFFECT OF RAIN ON SATELLITE COMMUNICATIONS EARTH TERMINAL RIGID RADOMES

ELECTRONIC SPACE STRUCTURES CORPORATION,
WEST CONCORD, MASSACHUSETTS

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THE EFFECT OF RAIN ON SATELLITE COMMUNICATIONS EARTH TERMINAL RIGID RADOMES

A. COHEN and A. SMOLSKI, ELECTRONIC SPACE STRUCTURES CORPORATION, WEST CONCORD, MASSACHUSETTS

INTRODUCTION

Measurements on the Andover, Maine Communication Satellite Earth Terminal air inflated radome have indicated serious effects due to rain on the antenna system performance. These results, published in the *Bell System Technical Journal*,[1] have been compared with an expected performance loss through water film thickness determined from a formula developed by D. Gibble of Bell Telephone Labs. Because the measured and the calculated values of the performance degradation appeared to be in agreement, two conclusions have been generally propagated, namely: (1) that water films predicted by the Gibble formulation do exist on spherical radomes, and (2) that other radomes subjected to rain will exhibit performance losses in accordance with the predicted water film thickness as demonstrated by the Andover, Maine installation.

In order to verify the effect that rain would have on a rigid metal space frame radome as contrasted to the air-inflated type, an extensive measurement program was conducted. The results of this measurement program have shown that both above conclusions are inaccurate.

REVIEW OF PREVIOUS RAIN EFFECT MEASUREMENT

The Bell article presented the transmission loss degradation due to rain on the air-inflated radome at the Andover, Maine Satellite Communication Earth Station. These measurements of transmission loss vs. the rate of rainfall are shown in Figure 1. It was stated that the high losses measured for the air-inflated radome were due to a water layer or water film on the radome surface. In order to theoretically account for the Andover performance, a formula for calculating this water film thickness as a function of the rate of rainfall was put forward by D. Gibble,[2] also of the Bell Telephone Labs.

Using Gibble's formula for calculating the water film thickness, t, caused by various rain rates:

$$t = \left(\frac{3\mu R r}{2w}\right)^{1/3}$$

where

μ = viscosity of water
R = radius of radome
r = rate of rainfall
w = density of water

and referring to the transmission loss vs. water film thickness curve of Figure 2,[3] one can construct a curve (Figure 1) which could represent the theoretical loss due to rain as a function of the rate of rainfall. One can observe that the correlation is good and might conclude that the measured losses were indeed due primarily to the various water films on the radome surface.

However, in the Gibble formula, only classical laminar flow has been assumed and, in addition, the initial

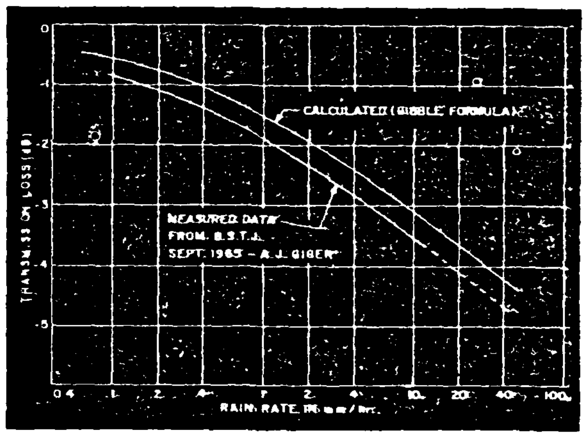

Figure 1 — Transmission loss vs. rain rate for the 210-foot radome of the Andover, Maine Satellite Station.

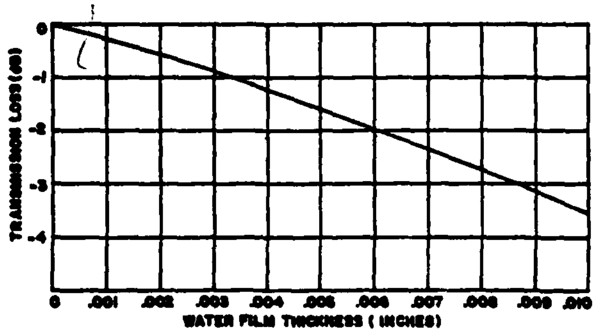

Figure 2 — Theoretical transmission loss vs. water film thickness. Laminate: ϵ = 4.15; tan δ = 0.015; "d" = 0.027. Water: ϵ=75; tan δ= 0.233. Normal incidence; frequency=4.17 GHz.

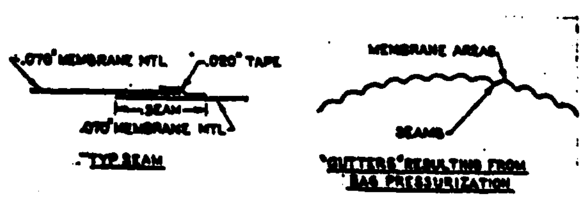

Figure 3 — Seam detail of air inflated radome.

velocity of the falling rain drops has been neglected. Both these effects may markedly reduce any possible film thickness on a spherical structure. In addition, several other questions relating to the general validity of the Andover experience remained unanswered. For example, rain water on top of an air-inflated radome as well as sag under its own weight tends to flatten it out. The resulting curvature effects can reduce the rate of water run-off from the radome surface thereby allowing more water to be accumulated. Another concern is the fact that the Andover antenna-radome placement is nonoptimum, the antenna being far off axis inside the radome. It is possible that this has seriously increased the reflected ground noise when water was present. Further, it is likely that the Andover radome fabric soaks up some moisture, at least the first outside fabric layers.

All of the air-inflated fabric types and coatings tend to age due to ultraviolet irradiation, and, in general, these radomes have a fairly short life, partly as a result of the subsequent depolymerization. As an example, Table I shows the results of the water absorption tests on the air-inflated type fabric as compared to the solid fiberglass laminate materials employed in rigid space frame radome designs. Note the relatively large percentage of water absorption for the air-inflated material and the resulting changes in the electromagnetic characteristics of the material.

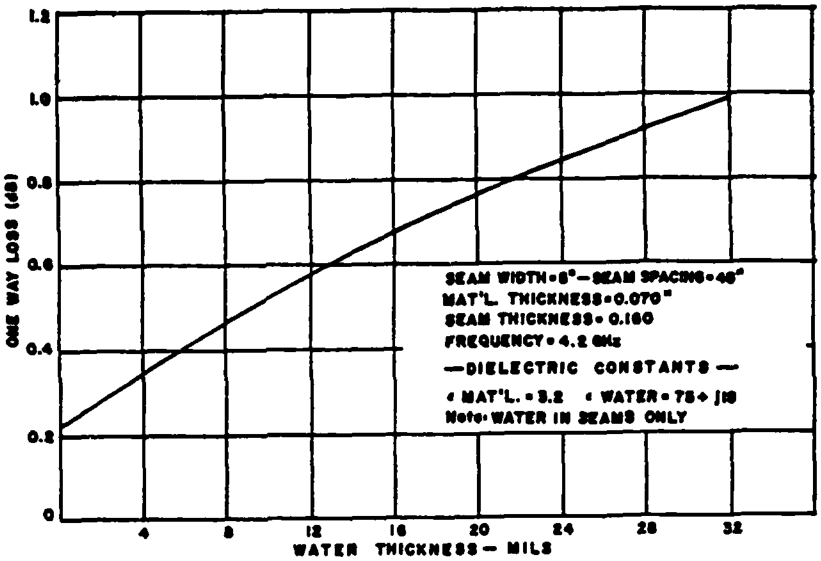

Figure 4 — Loss on Andover type radome.

In addition, the seams of an Andover type air-inflated radome are approximately 5-inch lap joints covered with 20 mil hypalon tape giving an effective thickness in excess of 0.160 inches. These seams are spaced approximately 4 feet apart at the equator tapering toward the top and bottom of the radome. The very important point here is that the seams are much stiffer than the main "window" area of the radome, and when the radome is inflated with internal air pressure, these seams may not expand to the same spherical surface as the main membrane areas. The result is, in effect, a corrugated surface with the main membrane areas protruding further outward than the seams, as illustrated in Figure 3.

Table I

Dielectric and Water Absorption Properties of Hypalon Coated Dacron Fabric and Fibrous Glass Reinforced Laminate*

Hypalon Coated Dacron Fabric

	3 GHz (Sample #1)			8.5 GHz (Sample #2)		
	K	Tan δ	Water Absorption % by Weight	K	Tan δ	Water Absorption % by Weight
Standard Conditions	3.12	0.014	——	3.12	0.012	——
After Water Immersion	6.79	0.080	13.2%	6.16	0.133	10.5%

Fibrous Glass Reinforced Laminate
(in accordance with MIL Specs MIL-R-7705, MIL-R-7575 and MIL-P-8013**)

	3 GHz			8.5 GHz		
	K	Tan δ	Water Absorption % by Weight	K	Tan δ	Water Absorption % by Weight
Standard Conditions	3.98	0.0113	——	3.97	0.012	——
After Water Immersion	4.02	0.0152	< 0.5%	4.02	0.015	< 0.5%

* *William B. Westphal, Laboratory for Insulation Research, MIT.*

** *MIL-R-7705 Radomes, general specification for.*
MIL-R-7575 Resin, polyester, low pressure laminating.
MIL-P-8013 Plastic materials, polyester resin, glass fiber base, low pressure laminated.

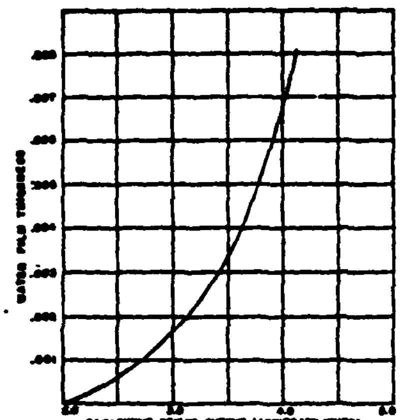

Figure 6 — Measured water film vs. bridge output.

Accordingly, the air-inflated radome is made up of vertical corrugated sections which, upon rainfall, can in effect act as rain gutters. The falling water thus can form very high density electromagnetic scattering ribs regularly spaced in the form of a diffraction grating. Figure 4 is a theoretical calculation of the transmission loss that is to be expected when rain water of various thicknesses flows in the seam corrugations only. Note that only small corrugations in the order of 0.03 to 0.04 inches are necessary in order for large losses to be experienced.

Since all of the above comments, including the possible deleterious rain channeling diffraction grating effects, exist for the air-inflated radome it was considered of major importance to thoroughly investigate and clarify the effects of rain on radomes. The following measurement program was therefore undertaken and completed.

MEASUREMENT PROGRAM

The primary objective of the measurement program was to determine the transmission loss which occurred due to rain on a faceted rigid radome surface. A secondary objective was to determine and measure within reasonable accuracy any water film which might form on the faceted radome surface.

Antenna-Radome Setup

In order to perform the transmission loss measurements a precision 30-foot diameter paraboloid was mounted on an azimuth turntable. The entire structure was enclosed with a 55-foot diameter metal space frame radome.* A 6-foot parabola was used at the transmitting station, and 4.2 GHz was selected as the operating frequency. The transmitted signal was modulated at 1000 cycles. At the receiving station the signal was detected, amplified and monitored on the expanded dB scale of a VSWR amplifier. The output was channeled into a recorder which recorded all test runs. A block diagram of the test setup is shown in Figure 5.

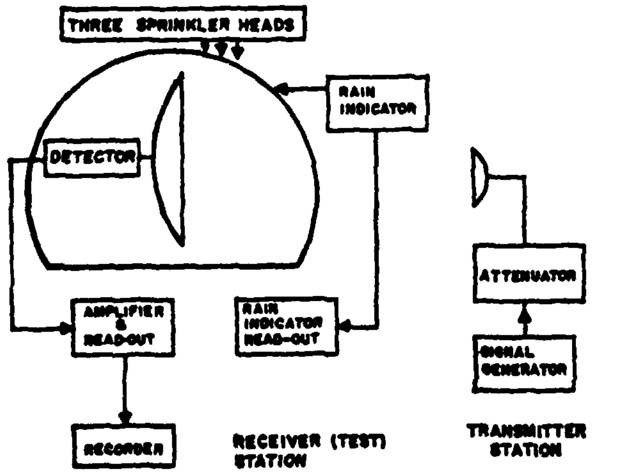

Figure 5 — Block diagram of measurement test setup.

Rain Field

To simulate rain on the radome surface a system of three rotating water sprinklers were positioned on top of the radome. Each sprinkler had two adjustable spray nozzles which rotated at approximately 140 rpm. Initial tests to establish the rain field pattern of the sprinklers were performed on a level plane. The spacing, relative position, nozzle setting and line water pressure were adjusted to create the desired rain field rates. Rainfall indicators were placed at various locations in the rain field pattern established by the sprinklers. The combination of adjusting the nozzle settings and sprinkler relative positioning, along with the rapid nozzle head rotation rates, created a very satisfactory simulated rain environment.

The rainfall indicators which were randomly placed at various locations parallel and perpendicular to the antenna aperture plane showed that a fairly uniform rain field could be readily generated. In this manner, rain fields with rain rates of approximately 10, 20 and 40 mm/hr. were established for the tests. The sprinkler system, after calibration, was then placed on the radome. Sample rainfall indicator tests were repeated in order to assure continuity of calibration and the final tests run.

With regard to the choice of rain rates established for this experiment, it should be noted that the percentage of time in any year for which given rainfall rates are exceeded are not generally available. However, a rainfall rate of 3 mm/hr. is likely to be exceeded for somewhat less than 2 per cent of an average year at Tokyo and for perhaps about 0.5 per cent of an average year at London or Paris. At Halifax, Canada and Washington, D. C. the corresponding values are both about 1 per cent. A rainfall rate of 25 mm/hr. is likely to be exceeded for percentages of an average year

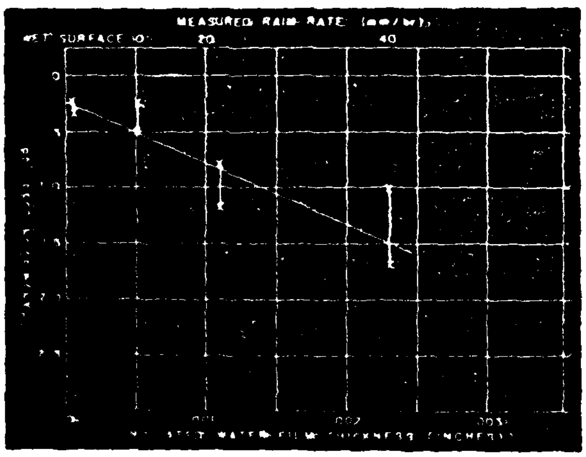

Figure 7 — Transmission loss vs. rain rate and indicated water film thickness.

* *Model No. M55-70 produced by Electronic Space Structures Corp., West Concord, Mass.*

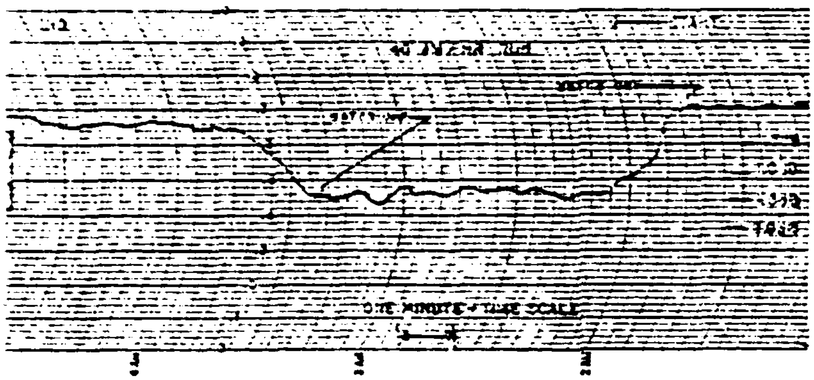

Figure 8 — Typical recorded data run (40 mm/hr.).

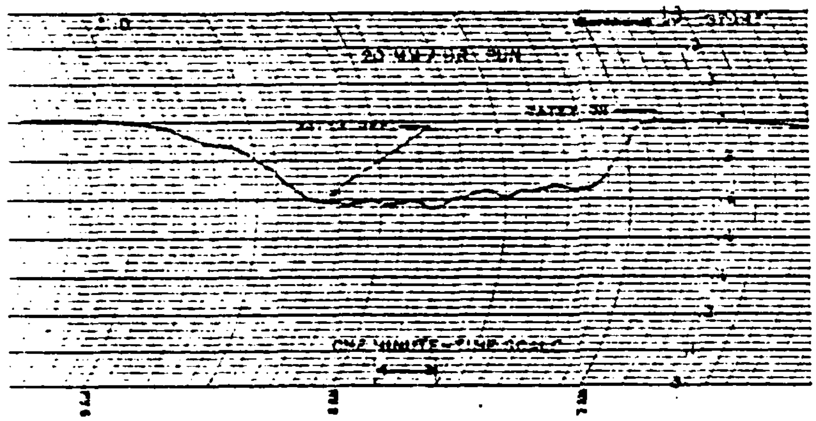

Figure 9 — Typical recorded data run (20 mm/hr.).

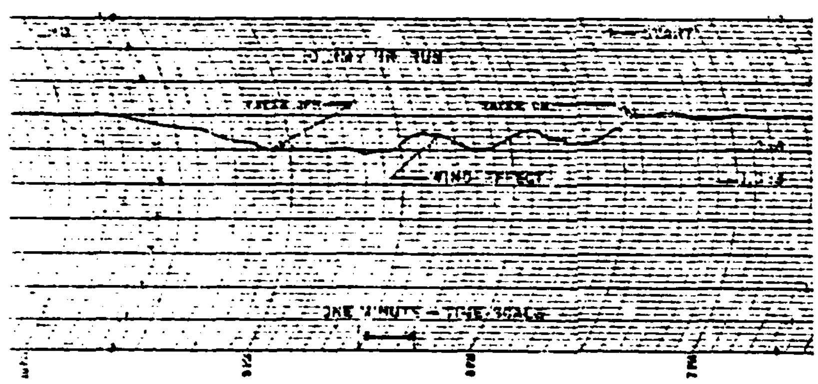

Figure 10 — Typical recorded data run (10 mm/hr.).

varying from about 0.1 per cent at Tokyo to perhaps less than 0.01 per cent at London or Paris. The range of rainfall rates thus established were more than adequate to cover practically all cases to be experienced.

Water Film Thickness Measurements

Considerable effort was expended to develop a measuring device which would indicate the water film thickness on the surface of the radome. The device selected was basically a capacitance type bridge, the sensing element being a split flat capacitor (4 x 1-1/2 inches) which was secured to the inside surface of the radome. Initially the bridge was balanced with a dry surface. As moisture, water droplets, water streaks or rivulets, or a water film forms on the outside surface, the bridge becomes unbalanced and an output voltage is generated. The capacity bridge was initially calibrated by depositing measured amounts of water over the area of the sensing capacitor, and a water thickness vs. bridge output curve was determined (Figure 6). During the simulated rain tests the sensing capacitor was mounted high on the 55-foot diameter radome at an angle of about 50° from the horizontal.

Measurement Results

A summary of measured transmission loss values is presented in Figure 7. Typical recorded data runs are shown in Figures 8, 9 and 10. An interesting run is that for the light rain (Figure 10) which shows the effect of the wind on the rainfield. This effect was only prevalent when the combination of light rain or mist and windy conditions existed during the measurements.

In all tests it was noted that it took less than two minutes to recover to within 0.2 dB of the reference signal level. From this observation and from further tests on a small test panel it was concluded that this last 0.2 dB loss was due to a wet surface or separated patches of very thin water films and droplets on the surface of the radome. In contrast, for the air-inflated radome at Andover, the received signal does not return to the essentially dry state for about 30 to 45 minutes, indicating that the high losses observed are not due to large water films but rather to the possible water absorption characteristics, diffraction grating effects, radome curvature effects, etc.

Figure 11 is a graph showing the measured transmission losses. These are compared with the expected transmission loss for a 55-foot radome that would be predicted, based on the Gibble formula and the Andover experience. Note that the maximum measured loss of 1.0 - 1.7 dB for the 40 mm/hr. simulated rainfall is in sharp contrast to (1) the loss of 3.4 dB which would be the value obtained for a film thickness derived from Gibble's formula or (2) the value of about 4.2 dB if one projected the calculated loss curve of the air-inflated radome (Figure 1).

A further observation was that with the heaviest rainfall rate simulated (40 mm/hr.), the water film thickness indicator read from 3.2 to 3.3 units which infers (from Figure 6) that the water film thickness was about 0.0025 inch. The transmission loss theoretically expected from a 0.0025 inch water film is about 0.75 dB (Figure 2). This agrees with the measured results with an accuracy within a factor of two.

An explanation of this discrepancy may be that only one water film thick-

ness indicator was available and installed during this test series. It is very possible that the indicated water film is not representative of the overall effective water film over the entire radome surface. Also, the water film indicator was calibrated by creating a uniform water film over the entire surface of the split sensing capacitor. However, rain on the faceted rigid radome surface took the form of streaks, rivulets and water film patches. Uniform films of any appreciable thickness simply did not exist on the rigid metal space frame radome. In any event, as an initial attempt at measuring and correlating the water film thickness, the results were enlightening.

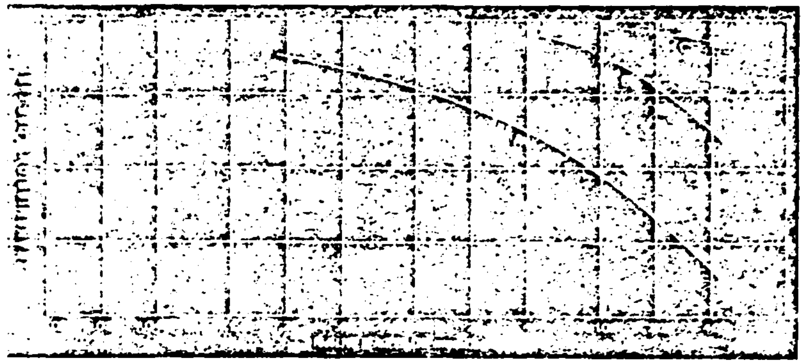

Figure 11 — Transmission loss vs. rain rate for 55-foot metal space frame radome. A. Theoretical performance (55-foot radome) — based on Gibble formula Andover type radome. B. Measured losses — untreated radome surface — 55-foot metal space frame radome. C. Measured loss — treated radome surface — 55-foot metal space frame radome.

Radome Surface Treatment

During visual observations of the radome surface during the simulated rain, it appeared that a pattern of rivulets, streaks and various water run-off paths developed. To enhance the water streak and rivulet formation and to inhibit or prevent any water film from forming on the radome, the surface was treated so as to decrease its wetability. As shown in Figure 11, the results were better than anticipated.

Using the highest simulated rain rate (40 mm/hr.), where previous measurements showed 1.0 - 1.7 dB losses, the measured transmission loss was less than 0.3 dB. The water film indicator correlated this value. The capacitance bridge output increased to only 2.2 units from a 2.0 reference. This increase was previously measured when the transmission loss was about 0.2 to 0.3 dB. Also when viewing the treated surface of the radome, during a heavy rainfall, it appeared that no uniform water film existed but that small and many water streaks had formed to rapidly run off the radome in narrow rivulets.

CONCLUSIONS

The results of the measurement program show that even with rain rates as high as 40 mm/hr. the transmission loss through the untreated surface of a 55-foot rigid metal space frame radome is only 1.0 - 1.7 dB. The transmission loss decreases to 0.8 - 1.2 dB at 20 mm/hr. and to 0.3 - 0.5 dB at 10 mm/hr.

If the radome surface is treated so as to inhibit the formation of any water film, the transmission loss will decrease to less than 0.3 dB at the highest rain rate of 40 mm/hr. Since rainfall rates seldom exceed 10 mm/hr. it should be clear that the effects of rain on a faceted rigid metal space frame radome can be practically eliminated.

Initial attempts at measuring and correlating the effective water film thickness were encouraging. Accuracy within a factor of two for this difficult experiment was achieved.

Recommendations for further effort include direct measurement of the noise temperature attributable to rain on the radome. In this regard, it should be noted that an upper bound to the noise temperature contribution resulting from rain on a rigid radome is, in fact, determined by the transmission efficiency measurements. For example, practically all of the transmission loss is in the form of scattered energy, and for a treated radome surface at 40 mm/hr. rain rates and for angles close to the horizon the worst condition would result in one half of the total transmission loss, or 0.15 dB, being directly absorbed by the "hot" earth. This would cause a noise temperature contribution of approximately 10° K to be exhibited.

Note that as the elevation angle increases (toward the zenith angle) this noise temperature contribution would decrease rapidly due to the shielding effect of the antenna inside the radome. In comparison, from the Andover type air-inflated radome experience,[1] a noise temperature contribution of as high as 65° K was recorded with a rain rate of approximately 2 mm/hr.!

In conclusion, this series of experiments shows that:

1. The Gibble formula for the prediction of water film thicknesses (and hence transmission efficiency) does not satisfy the measured values of transmission efficiency for rigid radomes in rain.

2. There is a marked difference between the performance of the air-inflated (as calculated from the Gibble formula) and faceted rigid metal space frame radomes in a rainfilled environment.

3. Water films of only a few thousandths can exist on inclined surfaces before rapid run-off occurs.

4. Appropriately treating the radome surface so as to further inhibit the formation of any water film can eliminate practically all the effects of rain, even in rainfalls with 40 mm/hr. rates.

ACKNOWLEDGMENTS

This work was sponsored by the Electronic Space Structures Corp. The 30-foot diameter precision reflector used in the program was supplied by Communication Structures, Inc., West Concord, Mass. William Moseley of Electronic Space Structures Corp. assisted in the physical setup, data accumulation and reduction. Dr. John Ruze, MIT/LL witnessed the experiments reported upon and presented the detailed results at the IEE Conference on the Design and Construction of Large Steerable Aerials (June 6 - 8, 1966).

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